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NIST Special Publication 917

MOIST

A PC Program for Predicting Heat and Moisture Transfer in Building Envelopes

Release 3.0

Douglas M. Burch and Dr. Joseph Chi

QC
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NO.917
1997

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Release 3.0

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September 1997

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National Institute of Standards
and Technology
Special Publication 917
Natl. Inst. Stand. Technol.
Spec. Publ. 917
47 pages (Sept. 1997)
CODEN: NSPUE2

U.S. Government Printing Office
Washington: 1997

For sale by the Superintendent
of Documents
U.S. Government Printing Office
Washington, DC 20402

ABSTRACT

This report is a User's Manual for a computer program called MOIST (Release 3.0). MOIST is a user-friendly, personal computer program that predicts the one-dimensional transfer of heat and moisture in building envelopes. With MOIST, you will be able to easily define a wall, cathedral ceiling, or low-slope roof construction. You will subsequently be able to predict the temperature and moisture content (or relative humidity) of the individual construction layers as a function of time of year. In addition, you will be able to investigate the effects of various parameters on the moisture accumulation within layers of the construction. For example, you will be able to conduct computer runs for different U.S. and Canadian cities, thereby investigating the effect of climate on moisture accumulation. You will be able to determine if a vapor retarder is needed, and if needed, where it should be placed relative to the other materials. MOIST allows the user to vary the building materials and their relative placement and analyze the effect of the water-vapor resistance offered by paint layers, wallpapers, and vapor retarders.

KEYWORDS: building technology; heat and moisture transfer; heat transfer; moisture analysis; moisture control; and moisture transfer.

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DISCLAIMER AND CONDITIONS

The input and output processor of MOIST (Release 3.0) is compiled in Microsoft Visual Basic (Version 3.0). The mathematical calculation algorithms are compiled in Microsoft Fortran (Version 5.0). The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) has consented to permit NIST to use their WYEC hourly weather data. The MOIST program comes with weather data for forty-six U.S. cities and five Canadian cities. These weather data will permit you to learn how to use the program and perform a significant amount of analysis for the United States and Canada.

Certain trade names and company products are mentioned in the text to specify the computer products and equipment needed to use MOIST. In no case, does such identification imply endorsement by the authors of these computer products and equipment, nor does it imply that the products are necessarily the best available for the purpose. Microsoft is a registered trademark, and Windows is a trademark of the Microsoft Corporation.

The authors have made a concerted effort to find and remove errors in this publication and the MOIST 3.0 software. However, we make no guarantee that they are free from errors or that the results produced with the software will be free of errors. We assume no responsibility or liability for the accuracy of the software or for the results which may come from its use.

Some copies of this publication are being disseminated without the diskettes containing the computer software. For more information or to request the software, contact Paula Svincek; NIST; Room B320, Building 226; Gaithersburg, MD 20899 or telephone (301) 975-5648 or e-mail moist@nist.gov.

SYSTEM REQUIREMENTS

MOIST 3.0 is designed to run on any IBM-compatible personal computer having a Microsoft Windows operating system. To run MOIST 3.0, you need at minimum the following equipment:

1) a DX or Pentium microprocessor;

2) Microsoft Windows 3.1, Microsoft Windows 95, or Microsoft Windows NT;

3) Five hundred kilobytes free memory available to execute a program from a DOS Window; the MOIST Program may run under less memory but problems may occur.

4) a hard disk with seven megabytes of available memory space;

5) a VGA or higher monitor; and

6) twelve or more files specified in the CONFIG.SYS file.

ACKNOWLEDGMENTS

The authors would like to thank the National Institute of Standards and Technology for funding the development of this program. In addition, the authors would like to thank ASHRAE for agreeing to permit us to release their WYEC hourly weather data with this program.

CHAPTER 1. INTRODUCTION

Brief Description of MOIST

MOIST (Release 3.0) is a user-friendly, personal computer program that predicts the one-dimensional transfer of heat and moisture. With MOIST, you will be able to easily define a wall, cathedral ceiling, or low-slope roof construction. You will subsequently be able to investigate the effects of various parameters on the moisture accumulation within layers of the construction. For example, you will be able to conduct computer runs for different U.S. and Canadian cities, thereby investigating the effect of climate on moisture accumulation. You will be able to determine if a vapor retarder is needed, and if needed, where it should be placed relative to the other materials. MOIST allows the user to vary the building materials and their relative placement and predicts the resulting moisture accumulation within each as a function of time for the selected climate. MOIST permits the evaluation of the effect of the water-vapor resistance offered by paint layers, wallpaper, and vapor retarders. Finally, MOIST can be used to generate guidelines and practices for controlling moisture.

Features of MOIST

The theory of MOIST is given in Appendix A. The algorithms in the program can predict moisture transfer in the diffusion regime through the capillary flow regime. The important effect of water evaporating from one place in the construction and condensing in another place is included in the model. The model predicts the moisture content, relative humidity, and temperature of the construction layers, as well as the heat and moisture transfer rates at the inside and outside surfaces of the construction. The program contains a heat and moisture property database for common building materials, and uses ASHRAE WYEC hourly weather data which is available for 51 cities of the United States and Canada. Data is input in a user-friendly Microsoft Windows environment. Result graphs are readily generated from within the program. During a simulation, the user can either specify a constant indoor temperature and relative humidity, or permit the winter indoor relative humidity to vary and be calculated from a moisture balance of the whole building.

Applications of MOIST

MOIST may be used for the following wall, unventilated cathedral ceiling, and low-slope roof applications:

1) predicting the winter moisture content in exterior construction layers and determining whether a vapor retarder is needed;

2) predicting the surface relative humidity at the construction layers in hot and humid climates, thereby analyzing the potential for mold and mildew growth;

3) determining the drying rates for materials containing original construction moisture;

4) investigating the performance of cold refrigeration storage rooms; and

5) analyzing the effect of moisture on heat transfer.

Limitations of MOIST

One of the most significant limitations of MOIST is that the model is one dimensional. This means that the model does not include the effect of framing members and two- and three-dimensional effects such as the vertical movement of moisture in an earth coupled wall. Moreover, the model does not include the exterior wetting of a construction by rain and the insulating effect and change in roof absorptance from a snow load. In addition, the model does not include the transfer of heat and moisture by air movement. The construction is assumed to be air tight.

Getting Help

After reading this manual, if you need help in using program MOIST, you may contact Doug Burch at (301) 975-6433 or at dburch@nist.gov.

CHAPTER 2. INSTALLING MOIST

Microsoft Windows 95

Insert the MOIST 3.0 Program Disk in your floppy disk drive. From the task bar at the bottom of your computer screen, click the **Start Button**, and then click **Run**. After the Run Dialog Box is displayed, enter "a:\setup" in the Open Text Box. Here "a:" is the floppy disk drive from which you are installing the program. If you are installing from drive "b:", then you would enter "b:\setup." Click the **OK** button to commence the installation process. During the installation, the following dialog box is displayed.

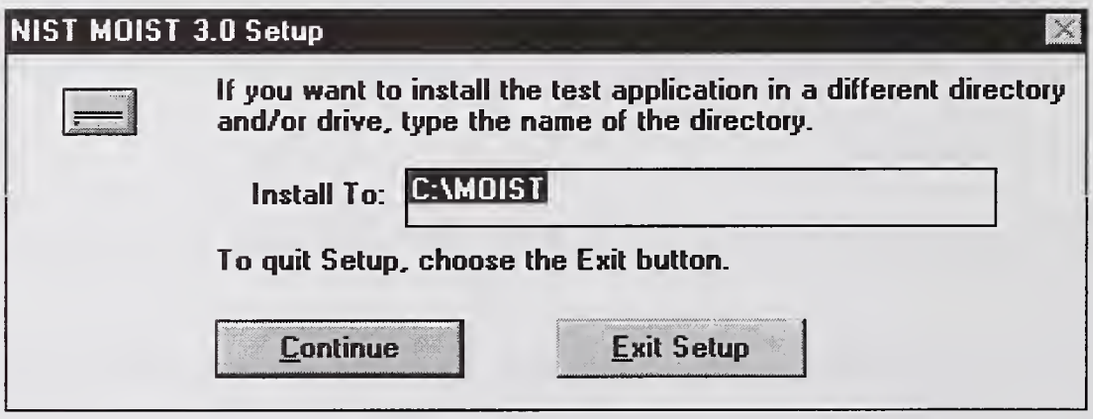
NIST MOIST 3.0 Setup
If you want to install the test application in a different directory and/or drive, type the name of the directory.
Install To:
C:\MOIST
To quit Setup, choose the Exit button.
Continue
Exit Setup

Figure 1. NIST MOIST 3.0 Setup Dialog Box.

If you want to install the MOIST program in a different directory and/or drive, type the name of the directory and/or drive in the **Install To** text box. Then, click **Continue** to proceed with the program installation. During the installation process, you will be prompted to insert the second installation disk into your computer.

Microsoft Windows 3.1

Insert the MOIST 3.0 Program Disk in your floppy disk drive. On the top menu bar of the Program Manager, click **File**. Then click **Run**. After the Run Dialog Box is displayed, enter "a:\setup" in the Open Text Box. Here "a:" is the floppy disk drive that you are using. If you are installing from drive "b:", then you would enter "b:\setup." Click the **OK** button to commence the installation process. During the installation, the NIST MOIST Setup Dialog Box shown above is displayed. If you want to install the MOIST program in a different directory and/or drive, type the name of the directory and/or drive in the text box. Then, click **Continue** to proceed with the program installation. During the installation process, you will be prompted to insert the second installation disk into your computer.

A description of the program files installed in the MOIST directory is given in Appendix B.

When MOIST is installed weather data for six cities (i.e., Madison, WI; Boston, MA; Portland, OR; Washington, DC; Atlanta, GA; and Lake Charles, LA) are installed in the MOIST Directory. Before you conduct a moisture analysis for another city, you must first install a weather data file for that particular city in the MOIST Directory of your hard drive. Compressed weather data files for other WYEC cities are contained on five disks supplied with the MOIST software package. Before using one of these files, you must copy it into the MOIST directory and extract it by entering its name. After extracting it, you may delete the compressed file to save space on your hard drive.

CHAPTER 3. GETTING STARTED

Starting the Program

After the installation process is completed, the MOIST Program Folder (Group) shown below is displayed on your computer screen.

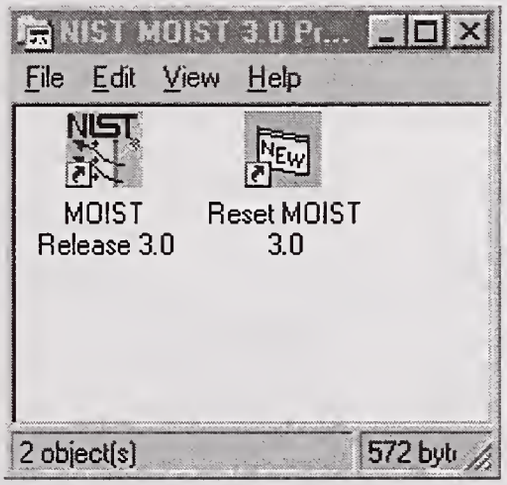

Figure 2. MOIST Program Folder (Group).

Two icons are displayed in the MOIST Program Folder (Group). Double-clicking the **MOIST Release 3.0** icon, starts the program. Double-clicking the **Reset MOIST 3.0** icon, resets the input

data files to their original state as installed.

Go ahead and start the program by double-clicking the **MOIST Release 3.0** icon. After the program starts, the Title Screen shown below is displayed.

MOIST Main Dialog Box

After a few seconds, the title screen will automatically disappear, and the MOIST Main Dialog Box

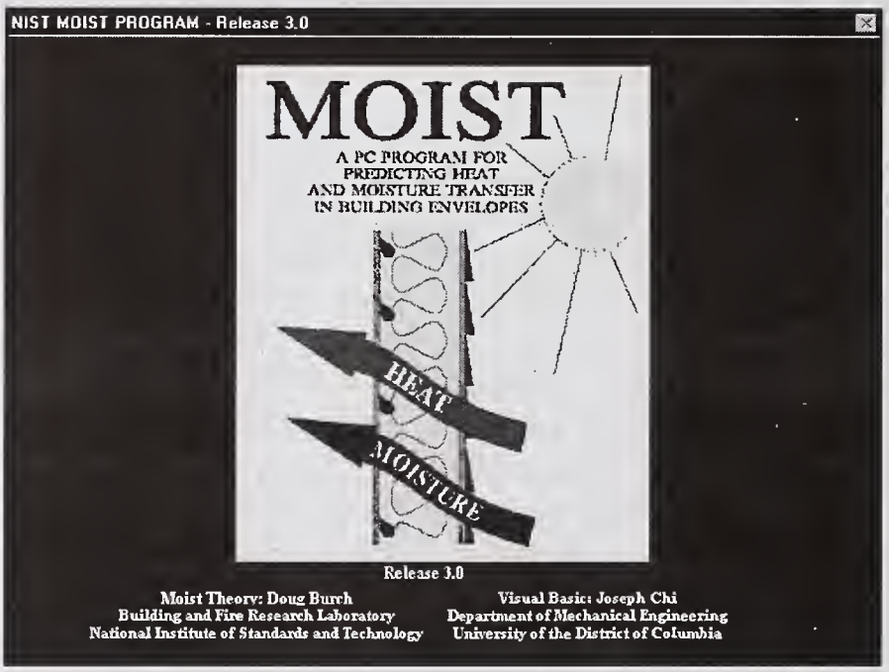

Figure 3. Title screen of the MOIST Program.

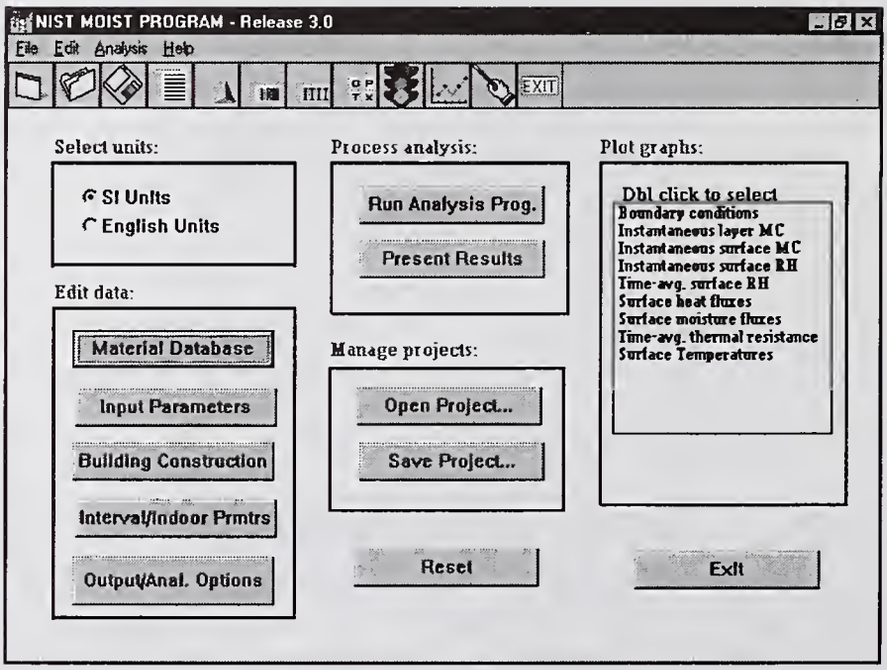

Figure 4. MOIST Main Dialog Box.

shown in Figure 4 is displayed. From this screen you may direct and launch a wide range of heat and moisture transfer projects.

Select Units:

Click on the appropriate button to select either **SI Units** or **English Units**.

From the MOIST Main Dialog Box, you may run the program by clicking command buttons, using pull-down menus, clicking tool icons on the tool bar, or by using short cut keys. These different ways to run the program are described below.

Command Buttons:

Single-clicking one of the command buttons takes you to a particular input data screen. Descriptions of the command buttons are given below:

Material Database. This command button takes you to the Material Database Dialog Box where you may enter a new material into the database, edit the properties of an existing material in the database, or delete a material from the database.

Input Parameters. This command button takes you to the Input Parameters Dialog Box where you can modify various input parameters for your simulation and select the WYEC hourly weather data used for the analysis.

Building Construction. This command button takes you to the Construction Data Entry Box where you can create a new building construction or modify an existing building construction.

Interval/Indoor Prmtrs. This command button takes you to the data box for specifying analysis intervals and indoor parameters. At this screen, you can specify the intervals over which you want a moisture analysis carried out. In addition, you can modify the parameters for the indoor climate model which permits the indoor relative humidity to vary and be calculated from a moisture balance of the whole building.

Output/Analysis Options. This command button takes you to the data box for selecting output and analysis options. At this screen, you may select which output files you would like the program to generate. In addition, you may select various analysis options such as activating the latent heat term in the temperature calculations.

The MOIST program may also be run by using pull-down menus and clicking on tool icons on the tool bar. The function and uses of the pull-down menus and tool icons on the tool bar are explained below.

Pull-Down Menus

There are four pull-down menus: **File**, **Edit**, **Analysis**, and **Help**. You may click on one of the menu options of a pull-down menu, or you may press the Alt Key and then the underlined letter of the menu option. The menu options of the pull-down menus are described below.

File Menu:

Reset	Reset MOIST to its initial state (as loaded)
Open File...	Load saved project files to the MOIST working area
Save File...	Save input files and analysis results of current MOIST session
Exit	Quit the current MOIST session

Edit Menu:

SI Units	Select SI system of units
English Units	Select English system of Units
Material Database	Update the material database
Input Parameters	Update the input parameters and select the weather data file
Building Construction	Update a building construction
Intervals and Indoor Parameters	Enter the analysis intervals and indoor climate model parameters
Output and Analysis Options	Select output files and analysis options

Analysis Menu:

Run Analysis Program	Start model analysis sequence
Present Results	Present the results (listing of all input data and nodal potentials, if full hardcopy documentation is selected)
Plot Graphs	Initiate graphs plotting sequence

Help Menu:

Introduction	Introduction to help (Users should read this first)
Tutorial	This will initiate a demonstration of the MOIST run, which takes about fifteen minutes to complete.
Select Units	Help in selecting units
Choose number of Nodes	Help in choosing number of nodes
Update Material Database	Help in updating the material database
Enter Input Parameters	Help in entering input parameters and selecting the weather data file
Enter Building Construction	Help in entering and modifying a building construction
Enter Analysis Intervals	Help in specifying analysis intervals
Enter Indoor Parameters	Help in entering parameters for the indoor climate model (variable RH)
Select Output Options	Help in selecting output files for an analysis
Run Analysis Program	Help in starting a moisture analysis sequence
Present Results	Help in viewing the output (listing of all input data and nodal potentials, if full hard copy documentation is selected) and getting a hardcopy
Plot Graphs	Help in plotting and printing graphs
Open and Save Files	Help in opening and saving MOIST project files
Reset and Exit	Help in resetting MOIST input files to their original state (as installed) and exiting the current session.
About MOIST program	Tells about the development of the MOIST program

Tool Icons on the Tool Bar

The tool bar at the top of the screen contains various tool icons that provide additional flexibility and convenience in using MOIST. Functions for the various tool icons and their equivalent menu options are listed in Table 1. Placing the cursor over a tool icon from the MOIST Main Dialog Box will cause a tool tip to be displayed.

Table 1. Tool Icons on the Tool Bar		
Tool Icons	Equivalent Menu Items	Functions and Use
	Reset	Reset MOIST input data files to their original state (as loaded)
	Open Project	Load saved project files to the MOIST program
	Save Project	Save data and analysis results of current MOIST project
	Material Database	Update the material database
	Input Parameters	Update input parameters and select weather data file
	Building Construction	Update building construction
	Analysis Intervals and Indoor Parameters	Update analysis intervals and indoor climate model parameters
	Output Files and Analysis Options	Select output files to be generated and analysis options
	Run Analysis Program	Start model analysis sequence
	Plot Graphs	Enter graph plotting sequence
	Present Results	Present the output (listing of all input data and nodal potentials, if full hard copy documentation is selected)
	Exit	Quit the current MOIST session

The **Reset** command button resets the input data files to their original state (as installed). The **Exit** Command Button causes you to leave the MOIST program and to return to the Windows operating system. All input data are saved to files.

The purposes of **Process analysis**, **Manage project**, and **Plot graph** are explained later in the manual.

CHAPTER 4. REVIEWING THE EDIT DATA SCREENS

We will now take you on a tour through the various screens used to edit the data for a moisture analysis session. The manual is written in SI units. Therefore, before beginning this chapter, select SI units by click the **SI Units** button on the MOIST Main Dialog Box.

Construction Data Entry Box

From the MOIST Main Dialog Box, single-click on the **Building Construction** command button. The screen shown in Figure 5 is now displayed on your computer screen.

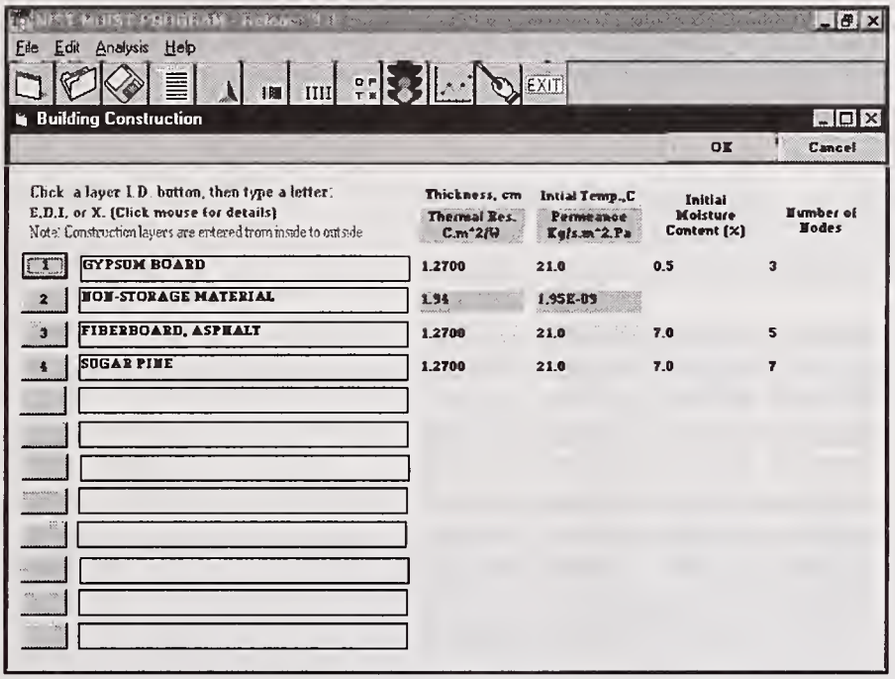
File Edit Analysis Help
EXIT
Building Construction
OK
Cancel
Click a layer I.D. button, then type a letter:
E,D,I, or X. (Click mouse for details)
Note: Construction layers are entered from inside to outside
Thickness, cm
Thermal Res. C.m^2/W
Initial Temp.,C
Permeance Kg/s.m^2.Pa
Initial Moisture Content (%)
Number of Nodes
1 GYPSUM BOARD 1.2700 21.0 0.5 3
2 NON-STORAGE MATERIAL 1.94 1.95E-09
3 FIBERBOARD, ASPHALT 1.2700 21.0 7.0 5
4 SUGAR PINE 1.2700 21.0 7.0 7

Figure 5. Construction Data Entry Box.

A four layer wall is shown in the Construction Data Entry Box. From the inside to the outside, each layer is displayed as a row in the table. *In using this program, building constructions must always be entered from inside to outside, and the number of layers in a wall must be ten or less.* This wall construction has the following layers: (1) gypsum board, (2) glass-fiber insulation (modeled as a non-storage material), (3) asphalt fiberboard, and (4) sugar pine. Layers 1, 3, and 4 are treated as storage layers. That is, they store both heat and moisture. The glass-fiber insulation is treated as a non-storage layer. That is, the storage of heat and moisture is neglected, and capillary transfer is neglected. Other examples where a layer may be treated as a non-storage layer include a vapor retarder, an air space, and a building paper.

Note that for each of the storage layers, the following four parameters are specified: thickness in cm (in.), initial temperature in °C (°F), initial moisture content (%), and the number of nodes. The initial moisture contents and temperatures are used to initialize the simulation results. It is recommended that the initial temperature be the indoor temperatures of the simulation. The initial moisture content of the materials should correspond to the equilibrium moisture content (EMC) at a relative humidity of 50%, unless the purpose of the MOIST simulation is to determine the rate of drying for initially moist construction. Recommended EMC values are given in the Table below.

Material	EMC Percent at 50% rh
Wood Base Materials	4.0-7.7
Masonry Materials	0.2-1.4
Glass Fiber Insulations	0.6
Gypsum Board	0.3
Plastic Insulations	1.9-3.8

EMC values may also be calculated by the sorption isotherm function [see eq (1) covered later in the manual]. Choosing a suitable number of nodes to achieve convergence of the mathematical solution is covered in Chapter 9.

For a non-storage layer, the following two parameters are specified: the thermal resistance in $°C \cdot m^2/W$ ($h \cdot ft^2 \cdot °F/Btu$) and the permenace in $kg/s \cdot m^2 \cdot Pa$ (perm) for the material layer. To modify a parameter, click on the parameter, and use the backspace, del, and numeric keys to change the number. Another option, is double-click on the parameter. The parameter becomes highlighted. When you enter a new parameter value, it replaces the old parameter value.

You may delete a layer by clicking the layer number to select the layer. Then type **D.** You may insert a layer above another layer by first selecting the layer by clicking its number. Then type **I.** The program now displays the Material Selection Box shown in Figure 6 on your computer screen.

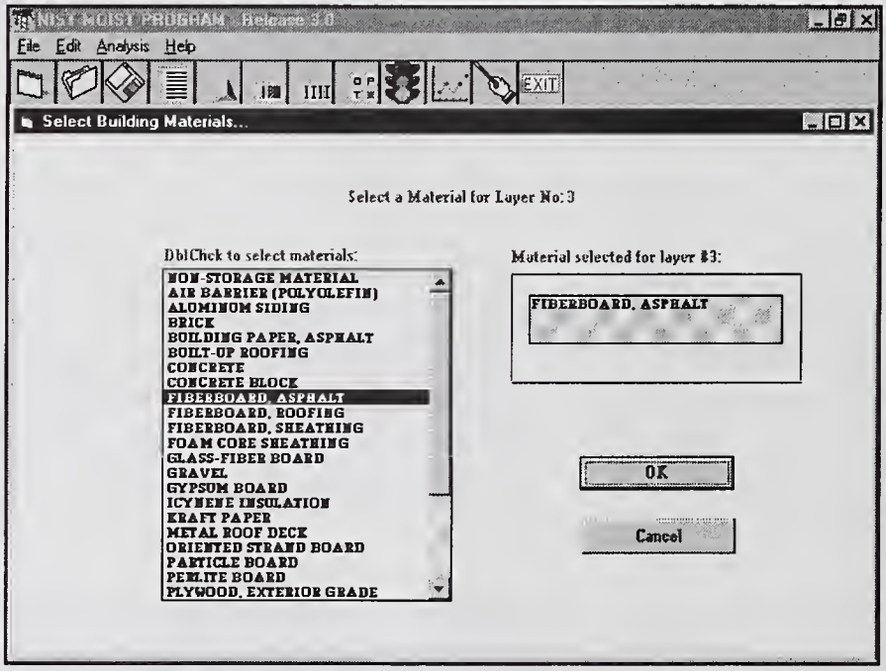

Figure 6. Material Selection Box.

You will now be prompted to select a new material. In the scroll box of materials, double-click on a material to select it. It will now appear in the material dialog box. Click the **OK** button to accept the material. The program will take you back to the Construction Data Entry Box (see Figure 5). You may now enter parameter values for the inserted material.

If you want to replace one of the materials with another material, then select the material by clicking its number. Then type **E**. The program will take you to Material Selection Box (see Figure 6). Select a new material, click on the **OK** button, and then enter its parameter values.

You must obey several rules in using the Construction Data Entry Box. First, the layers must be specified from inside to outside. Second, the first and last layers must be storage layers. It is worth mentioning that you may put several non-storage layers adjacent to each other. However, if you do that, the analysis algorithms of the MOIST model will combine the adjacent non-storage layers into a single layer. This will cause the depiction of layers on the plot screen to be renumbered accordingly.

When you have completed updating the building construction, type an **X** function to exit the editing sequence if a layer number is still highlighted, and then click on the **OK** button. This will incorporate the updated construction into the current moisture analysis session. Alternatively, you may click on the **Cancel** button to cancel the revisions to the building construction.

Input Parameters Dialog Box

From the MOIST Main Dialog Box (see Figure 4), click the **Reset** button to restore all input parameter values to their original state (as installed). Now click the **Input Parameters** command button. The program now takes you to the Input Parameters Dialog Box shown in Figure 7.

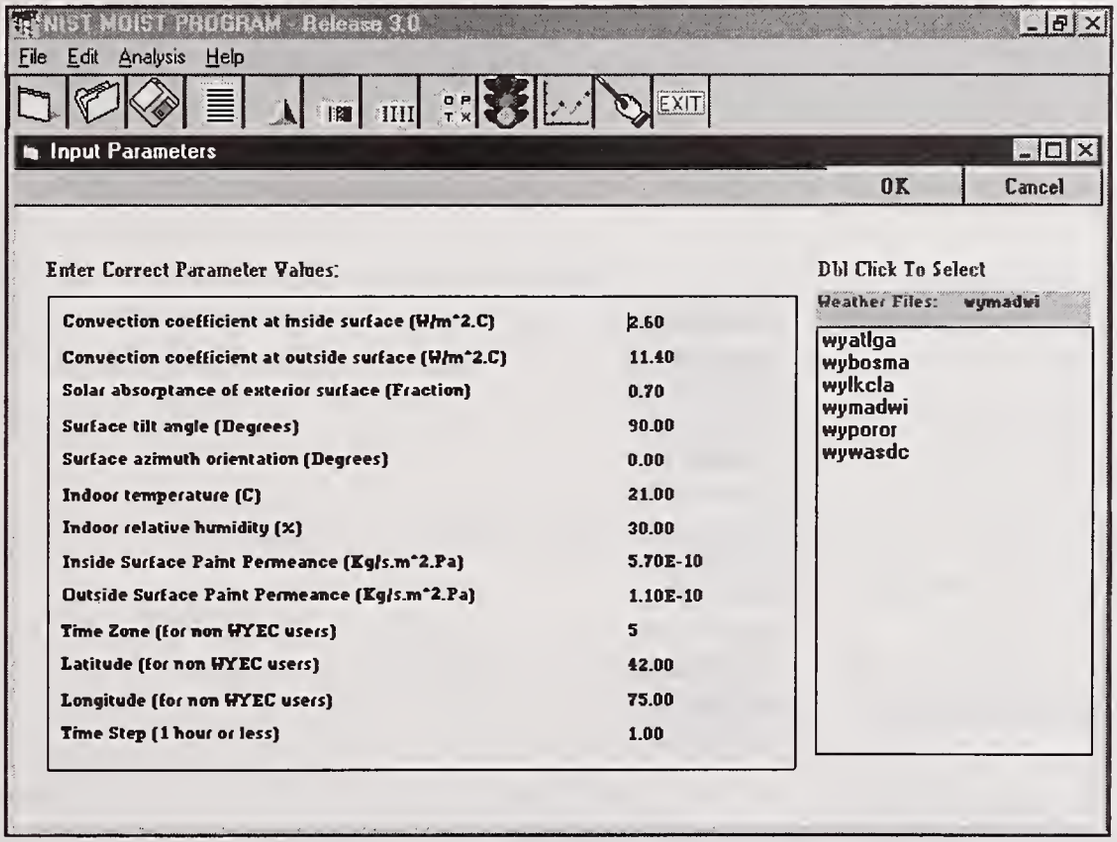

Figure 7. Input Parameters Dialog Box.

The input parameters are defined below.

Convection coefficient at the inside surface. This is the coefficient of heat transfer due to the movement of air at the inside surface of the construction. The coefficient does not include the transfer of heat by radiation. The authors recommend that you use a value of 2.6 $W/m^2 \cdot °C$ (0.46 $Btu/h \cdot ft^2 \cdot °F$).

Convection coefficient at the outside surface. This is the coefficient of heat transfer due to the movement of air at the outside surface of the construction. The coefficient does not include the transfer of heat by radiation. The authors recommend that you use a value of 11.4 $W/m^2 \cdot °C$ (2.0 $Btu/h \cdot ft^2 \cdot °F$).

It is worth mentioning that the surface conductances given in Table 1 of Chapter 22 of the 1993 ASHRAE Handbook of Fundamentals are total conductances and include the radiation conductance. When using these ASHRAE conductances, you must subtract the radiation conductance from the value given in the ASHRAE table. A moisture analysis is usually not very sensitive to reasonable variations in these coefficients.

Solar absorptance at exterior surface. This parameter is the fraction of the incident solar radiation that is absorbed by the surface. The program comes loaded with a value of 0.7. We recommend a value of 0.2 for light-colored surfaces, 0.5 for medium-colored surfaces, and 0.8 for dark-colored surfaces.

Surface tilt Angle. This is the surface tilt with respect to a horizontal plane expressed in angular degrees. Select 90° for a vertical surface and 0° for a horizontal surface.

Surface azimuth orientation. This is the surface compass azimuth expressed in angular degrees clockwise from North. A north azimuth is 0°, and a west azimuth is 270°.

The next two parameters are used when the indoor temperature and relative humidity are held constant during a simulation. This mode of operation occurs when the indoor climate model is not selected as an analysis option (see the section on the Data Box for Selecting Output and Analysis Options). *If the indoor climate model is selected, then the next two parameters may not be revised and are not used in the computer analysis.*

Indoor temperature. This is the indoor dry-bulb temperature expressed in °C (°F) which is held constant during the computer simulation.

Indoor relative humidity. This is the indoor relative humidity expressed as a percent which is held constant during the computer simulation.

Inside surface paint permeance. This is the water-vapor permeance of the inside surface covering (paint or wallpaper) expressed in $kg/s \cdot m^2 \cdot Pa$ (perm).

Outside surface paint permeance. This is the water-vapor permeance of the outside surface covering (paint, stain, etc.) expressed in $kg/s \cdot m^2 \cdot Pa$ (perm).

Some guidelines on choosing an appropriate value for paint permeance is given below. Latex paint systems (primer and top coat) have permeances ranging from 2.9×10^{-10} - 8.6×10^{-10} kg/s·m^2·Pa (5-15 perm) depending on the manufacturer. If you do not know the exact value of the permeance of the your latex paint, the authors recommend that you use a value of 5.7×10^{-10} kg/s·m^2·Pa (10 perm). Oil-base paints have a permeance ranging from 5.7×10^{-11} -1.7×10^{-10} kg/s·m^2·Pa (1-3). If you do not know the exact value of the permeance of the your oil-base paint, the authors recommend that you use a value of 1.1×10^{-10} kg/s·m^2·Pa (2 perm). Vapor retarder (vapor barrier) paints have a permeance less than 5.7×10^{-11} kg/s·m^2·Pa (1 perm). If a wallpaper is applied to the surface instead of a paint, then enter the permeance value of the wallpaper. For vinyl wallpaper, the authors recommend using a permeance of 2.9×10^{-11} kg/s·m^2·Pa (0.5 perm). *If a surface has no paint or wallpaper applied, then enter a value of* 5.7×10^{-6} kg/s·m^2·Pa *(100000 perm).*

The next three parameters are for non-WYEC users only. When an official WYEC weather data file name is specified, the next three parameters are not used by the MOIST program. The procedure for using non-WYEC weather data is given in Appendix C.

Time zone (for non WYEC users). The global circumference of the earth is divided into 24 time zones (each 15 degrees) measured west of the Greenwich Meridian. The time zone is equal to the longitude of the location divided by 15, rounded to the nearest whole number.

Latitude (for non WYEC users). The angular position of your weather data location expressed in degrees north or south of the equator, north positive, south negative ($-90° \leq$ latitude $\leq 90°$).

Longitude (for non WYEC users). The angular position of your weather data location expressed in degrees west of the Greenwich Meridian. ($0° \leq$ longitude $\leq 360°$).

Time step. This is the time step used in the analysis expressed in hours. It must be 1 hour or less. In most simulations, a 1 hour time step will provide reasonable results. However, when MOIST is used to model low density insulation as a storage layer, then a smaller time step may sometimes be needed to achieve a reasonable simulation. If too large a time step is used in this case, then MOIST may become unstable, resulting in unreasonable fluctuations in moisture content. Further information on modeling low density insulation as a storage layer is given in Chapter 10.

When you have completed updating the input parameters, click the **OK** button. This will incorporate the revised parameters into the current moisture analysis session. Alternatively, click the **Cancel** button, if you want to cancel the revisions just performed.

Selecting Weather Data for the Analysis

From the Input Parameters Dialog Box, you may also selected the weather data to be used in the analysis. Weather data is selected by double-clicking on the name of the weather data file contained in the Weather Data Dialog Box. All the weather data files in the MOIST directory are displayed in the dialog box. When the MOIST program is initially installed, weather data for six U.S. cities is installed in the MOIST directory. The six cities include: Madison, WI; Boston, MA; Washington, DC; Atlanta, GA; Portland, OR; and Lake Charles, LA.

Weather data for 45 other U.S. and Canadian cities are provided with the program and may be installed in the MOIST directory for use with the program. They may be installed by copying the appropriate compressed file into the MOIST directory. Entering the name of the file from the MOIST directory will cause the file to be extracted into an uncompressed format. After a file is extracted, you may delete the compressed file to save hard disk space. Procedures for using non-WYEC weather data with the MOIST program are described in Appendix C.

Data Box for Specifying Analysis Intervals and Indoor Parameters

From the MOIST Main Dialog Box, click the **Interval/Indoor Prmtrs** command button. The program will now display the Data Box for Specifying Analysis Intervals and Indoor Parameters shown in Figure 8.

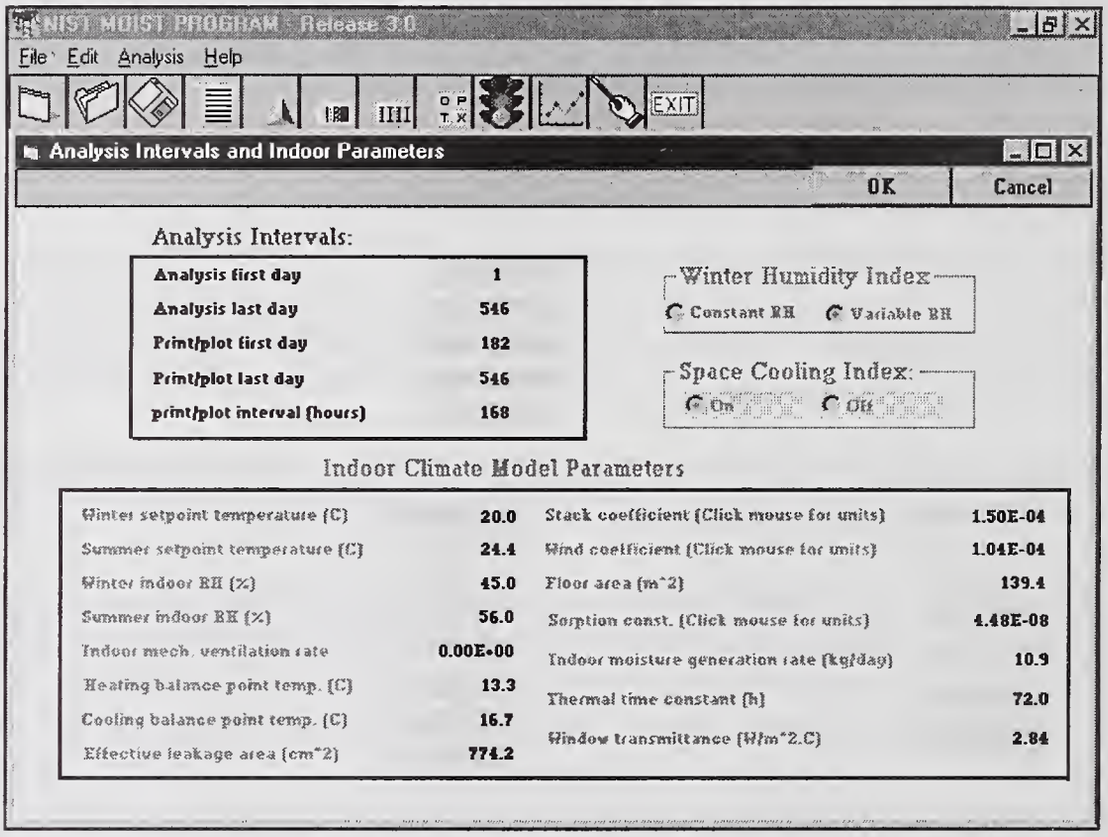
NIST MOIST PROGRAM : Release 3.0
File Edit Analysis Help
EXIT
Analysis Intervals and Indoor Parameters
OK
Cancel
Analysis Intervals:
Analysis first day 1
Analysis last day 546
Print/plot first day 182
Print/plot last day 546
print/plot interval (hours) 168
Winter Humidity Index
Constant RH
Variable RH
Space Cooling Index:
On
Off
Indoor Climate Model Parameters
Winter setpoint temperature (C) 20.0
Summer setpoint temperature (C) 24.4
Winter indoor RH (%) 45.0
Summer indoor RH (%) 56.0
Indoor mech. ventilation rate 0.00E+00
Heating balance point temp. (C) 13.3
Cooling balance point temp. (C) 16.7
Effective leakage area (cm^2) 774.2
Stack coefficient (Click mouse for units) 1.50E-04
Wind coefficient (Click mouse for units) 1.04E-04
Floor area (m^2) 139.4
Sorption const. (Click mouse for units) 4.48E-08
Indoor moisture generation rate (kg/day) 10.9
Thermal time constant (h) 72.0
Window transmittance (W/m^2.C) 2.84

Figure 8. Data Box for Specifying Analysis Intervals and Indoor Parameters.

Under Analysis Intervals,

Analysis first day. This is a pointer that instructs the program to carry out an analysis starting with the Julian calendar day specified in the data field. In the Julian calendar, the days of the year are numbered consecutively. For example, Julian day 45 refers to February 14.

Analysis last day. This is a pointer that instructs the program to carry out an analysis ending with the Julian calendar day specified in the data field.

Print/plot first day. This is a pointer that instructs the program to send print and plot data to specified output files starting with the Julian day specified in the data field.

Print/plot last day. This is a pointer that instructs the program to send print and plot data to specified output files ending with the Julian day specified in the data field.

The above print/plot pointers may be different than the analysis pointers, thereby making it possible to include a pre-conditioning period in the computer analysis when print and plot data are not sent to the selected output files. Here the term "pre-conditioning period" denotes a period of time, placed in front of the period of analysis, which serves to initialize the simulation results so that they are independent of assumed initial moisture content and temperature. The authors recommend using a 6-month pre-conditioning period, unless the purpose of the MOIST simulation is to predict the drying rate of initially wet construction.

Print/plot interval (hours). This is how often print and plot data are sent to output files. For many analyses, a print/plot interval of 168 h (or once a week) is an appropriate selection.

When conducting a 1-year moisture analysis in cold climates, it is convenient to put the winter in the middle of the analysis period. In a similar fashion, when conducting a 1-year analysis in a hot and humid climate, it is convenient to put the summer in the middle of the analysis period. For the case of including a 6-month pre-conditioning period, the following parameter values are recommended:

Analysis	**Winter**	**Summer**
First Day	1	182
Last Day	546	730
Printing/Plotting		
First Day	182	366
Last Day	546	730
Print/Plot Interval	168	168

If you want to eliminate the pre-conditioning period, then set the first day of the analysis equal to the first day of printing and plotting.

The other parameters shown in this data box (i.e., Winter Humidity Index, Space Cooling Index, and Indoor Climate Model Parameters) pertain to the indoor climate model. To use and revise these parameters, go to the analysis options (Data Box for Selecting Output and Analysis Options) and select the indoor climate model. *If the indoor climate model is not selected, then these parameters may not be revised and are not used in the computer analysis.* A mathematical description of the indoor climate model is given in Appendix A. The parameters for the indoor climate model are described below.

Winter Humidity Index. When **Constant RH** is selected, the winter indoor RH will be maintained at the value specified in the Indoor Climate Model Parameters. This option allows separate indoor

RH and temperature values to be specified during the winter and summer. This option could be used to simulate a house which is air conditioned during the summer and humidified during the winter. When **Variable RH** is selected, the winter indoor RH will be permitted to vary and will be calculated from a moisture balance of the whole building. Here the indoor moisture generation rate and building air tightness serve as input. This variable indoor relative humidity model should only be used for cases where the interior of a residential building may be modeled as a single zone having a uniform temperature and relative humidity. *This featured should not be used for non-residential buildings.*

Space Cooling Index. When **On** is selected, space cooling will be provided during the summer at the summer set point temperature specified in Indoor Climate Model Parameters. When **Off** is selected space cooling is not provided and the windows are assumed to be open during the summer. The indoor temperature and relative humidity are then assumed to be equal to the outdoor values.

Under the Indoor Climate Model Parameters:

Winter set point temperature. This is the set point temperature for space heating.

Summer set point temperature. This is the set point temperature for space cooling.

Winter indoor RH. This is the winter indoor relative humidity used in the analysis when the Indoor Humidity Index is set to **Constant RH**. When the Indoor Humidity Index is set to **Variable RH**, this parameter is not used in the analysis.

Summer indoor RH. This is the summer indoor relative humidity used in the analysis when the Space Cooling Index is set to **On**. When the Space Cooling Index is set to **Off**, this parameter is not used in the analysis, and the indoor relative humidity is equal to the outdoor value. The authors recommend using a value of 56%.

Indoor mech. ventilation rate. This is the volumetric ventilation rate of the indoor space provided by mechanical equipment during the winter. *This value is the actual value rather than the rated value.* If no mechanical ventilation is provided, then use a value of 0.0. During the summer, the indoor relative humidity is either assumed to be equal to a specified value provided by the air conditioning equipment or equal to the outdoors value if the windows are opened. In this situation, mechanical ventilation is not included in the analysis.

Heating balance point temp. This is the balance point temperature for space heating. When the weekly space heating loads are plotted versus average outdoor temperature, this is the average outdoor temperature at which the weekly space heating loads become equal to zero. The authors recommend using a value of 13.3 °C (56.0 °F) for a well insulated house and 16.7 °C (62.0 °F) for a poorly insulated house.

Summer balance point temp. This is the balance point temperature for space cooling. When the weekly space cooling loads are plotted versus average outdoor temperature, this is the average outdoor temperature at which the weekly space cooling loads become equal to zero. The authors recommend using a value of about 19.4 °C (67.0 °F).

Effective leakage area. If all the leakage area of the whole house were replaced with a single sharp-edge orifice, then the effective leakage area would be the area of the orifice which would produce the same airflow rate as the actual leakage area in the whole house. The authors recommend using values of 355 cm^2 (55 in^2) for a tight house, 710 cm^2 (110 in^2) for a typical house, and 1420 cm^2 (220 in^2) for a leaky house.

The next two coefficients are used in the Lawrence Berkeley Laboratory (LBL) infiltration equation (see Eq. A-12 in Appendix A) to calculate the house infiltration rate from the driving forces of inside-to-outside temperature difference and wind speed.

Stack coefficient. This is the coefficient for the inside-to-outside temperature difference. The authors recommend using a value of 0.000145 $(L/s)^2 \cdot cm^{-4} \cdot °C^{-1}$ (0.0156 $cfm^2 \cdot in^{-4} \cdot °F^{-1}$). Other values are given in Table 6, Chapter 23, 1993 ASHRAE Handbook of Fundamentals.

Wind coefficient. This is the coefficient for the wind speed. The authors recommend using a value of 0.000104 $(L/s)^2 \cdot (cm)^{-4} \cdot (m/s)^{-2}$ [0.0039 $cfm^2 \cdot in^{-4} \cdot mph^{-2}$]. Other values are given in Table 8, Chapter 23, 1993 ASHRAE Handbook of Fundamentals.

Floor area. This is the floor area of the indoor conditioned space. Unconditioned spaces are excluded. A typical house has a floor area of about 139.4 m^2 (1,500 ft^2).

Sorption const. This is a moisture storage parameter (per unit floor area) used in the moisture balance of the whole building to include the effect of moisture storage at interior surfaces. The authors recommend using a value of 4.5×10^{-8} $kg/s \cdot m^2$ (0.33×10^{-4} $lb/h \cdot ft^2$). Other values are given in TenWolde (1994).

Indoor moisture generation rate. This is the moisture release rate for occupant-related activities expressed in kg/day (lb/day).

Thermal time constant. This is another moisture storage parameter used in the moisture balance of the whole building to include the effect of moisture storage at interior surfaces. The authors recommend using a value of 72 h.

The authors have found that moisture accumulation in the building envelope is fairly insensitive to reasonable variations in the above two moisture storage parameters.

Window transmittance. This is the center-of-glass thermal transmittance for the windows. The authors recommend using a value of 6.2 $W/m^2 \cdot K$ (1.1 $Btu/h \cdot ft^2 \cdot °F$) for single-pane windows and 3.2 $W/m^2 \cdot K$ (0.57 $Btu/h \cdot ft^2 \cdot °F$) for double-pane windows. Window thermal transmittance values for various glazing systems are given in Table 5, Chapter 27, 1993 ASHRAE Handbook of Fundamentals. In the MOIST program, the window transmittance is used to calculate an inside glass surface temperature which is the maximum sustainable indoor dew-point temperature, thereby limiting the indoor relative humidity.

When you have completed updating the Data Box for Specifying Analysis Intervals and Indoor Parameters, click on the **OK** button. This will incorporate the revised parameters into the current

moisture analysis session. Alternatively, you may click the **Cancel** button to cancel the revisions just performed.

Data Box for Selecting Output and Analysis Options

From the MOIST Main Dialog Box, click the **Output/Analysis Options** command button. The program will now display the Data Box for Selecting Output and Analysis Options shown in Figure 9.

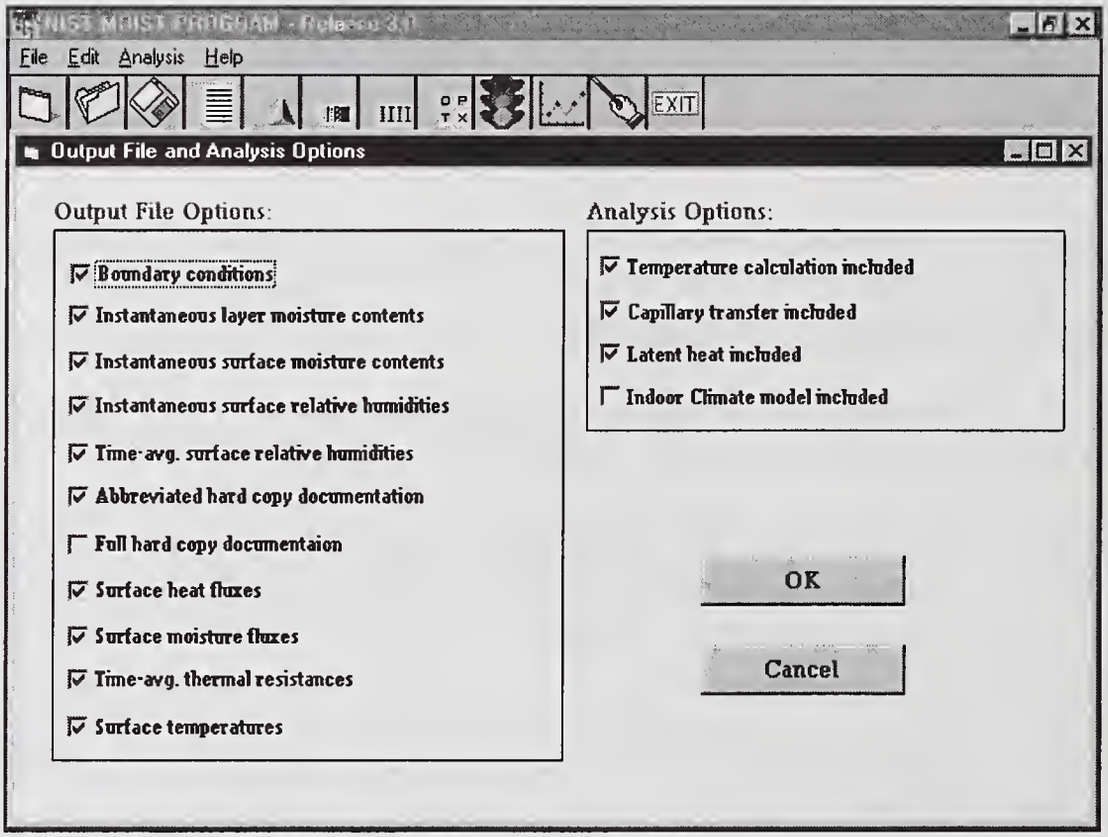

Figure 9. Data Box for Selecting Output and Analysis Options.

Under Output File Option, you may select which output files will be generated by the program. MOIST sends results to the selected files at the print/plot interval. The output file options are described below.

Boundary conditions. This option is a snapshot (at the print/plot interval) of the boundary conditions (i.e., indoor temperature, indoor water-vapor pressure, indoor relative humidity, outdoor temperature, outdoor water-vapor pressure, incident solar flux less long-wave sky radiation, and outdoor dew-point temperature). All values are time-averaged over the print/plot interval.

Instantaneous layer moisture contents. This option is a snapshot (at the print/plot interval) of the moisture contents of the construction layers. Each moisture content is averaged across the thickness of the layer. Moisture content is defined as the mass of water in a material divided by its dry weight.

Instantaneous surface relative humidities. This option is a snapshot (at the print/plot interval) of the surface relative humidities of the construction layers. The surface relative humidities at adjacent surfaces will not be exactly equal. This is because the surface relative humidity is taken to be the

value of the nearest finite-difference node to the surface. If adjacent values are too much different, then you should increase the number of nodes in the adjacent layers.

Time-avg. surface relative humidities. This option is the same as the above, except that the values are time-averaged over the print/plot interval.

Abbreviated hard copy documentation. This option is a listing of all the input data parameters contained in the dialog boxes. After a MOIST session, you can view these input data parameters in a dialog box by clicking **Present Results**.

Full hard copy documentation. This option contains a listing of all the input data parameters plus snapshots (at the print/plot intervals) of the nodal potentials (i.e., temperature, moisture content, water-vapor pressure, and logarithm of capillary pressure). After a MOIST session, you can view these input data parameters and nodal potentials in a dialog box by clicking **Present Results**. In the sample problem that comes pre-loaded with the program, the size of the file containing the full hard copy documentation is 58 kbytes. *The user is cautioned that this file can become quite large when an analysis interval less than 168 hours (1 week) is used in the program.*

Surface heat fluxes. This option contains the heat fluxes at the inside and outside boundaries of the building construction at the print/plot interval. The values are time-averaged over the print/plot interval.

Surface moisture fluxes. This option contains the moisture fluxes at the inside and outside boundaries of the building construction at the print/plot interval. The values are time-averaged over the print/plot interval.

Time-avg. thermal resistance. This option contains the time-average thermal resistance of the building construction. Each value is computed by dividing the time-average (surface-to-surface) temperature difference across the building construction by the time-average heat flux at the inside boundary. When the heat flux and temperature difference are close to zero, small computational errors may propagate into unreasonable thermal resistance values.

Surface temperatures. This option is a snapshot (at the print/plot interval) of the surface temperature of the construction layers. Since each of the surface temperatures is taken to be the value of the finite-difference node nearest to that surface, adjacent surface temperatures will not be exactly equal. If adjacent values are too much different, then you should increase the number of nodes in adjacent layers.

If the storage space on your hard drive is limited, you may save storage space by not selecting some of the output file options. However, if an output file option is not selected, the output parameters in this file may not be plotted after a MOIST analysis.

In this data box, you may also select the following analysis options:

Temperature calculation included. This option includes the temperature calculation in the analysis. *For most practical applications, you will select this option.* If this option is not selected, the initial

temperatures of the layers specified in the Construction Data Entry Box (see Figure 5) are maintained during the entire simulation. The material temperatures will not vary.

Capillary transfer included. This option includes capillary transfer in the simulation. If this option is not selected, then moisture transfer will be by water-vapor diffusion and capillary transfer will be excluded. *For most applications, you will select this option.*

Latent heat included. This option includes latent heat (i.e., the effect of water evaporating from one place and condensing in another place) in the temperature calculations. *For most applications, you will select this option. However, the inclusion of latent heat in some applications where low density insulation is modeled as a storage layer and becomes wet may cause the MOIST model to become unstable (see Chapter 10).*

Indoor climate model included. When this option is not selected, the indoor temperature and relative humidity will be held constant during the MOIST analysis. The model will use the indoor temperature and relative humidity given in the Input Parameters Dialog Box (see Figure 7). On the other hand, if this option is selected, then the indoor climate model will be used in the moisture analysis. The Winter Humidity Index, the Space Cooling Index, and the Indoor Parameters specified in Figure 8 will be used in the analysis.

When you have completed updating the Data Box for Selecting Output and Analysis Options, click the **OK** button. This will incorporate the revised parameters into the current moisture analysis session. Alternatively, you can click the **Cancel** button, if you would like to cancel the revisions just performed.

Material Database Dialog Box

From the MOIST Main Dialog Box (see Figure 4), click the **Material Database** command button. The Material Database Dialog Box shown in Figure 10 will be displayed on your computer screen.

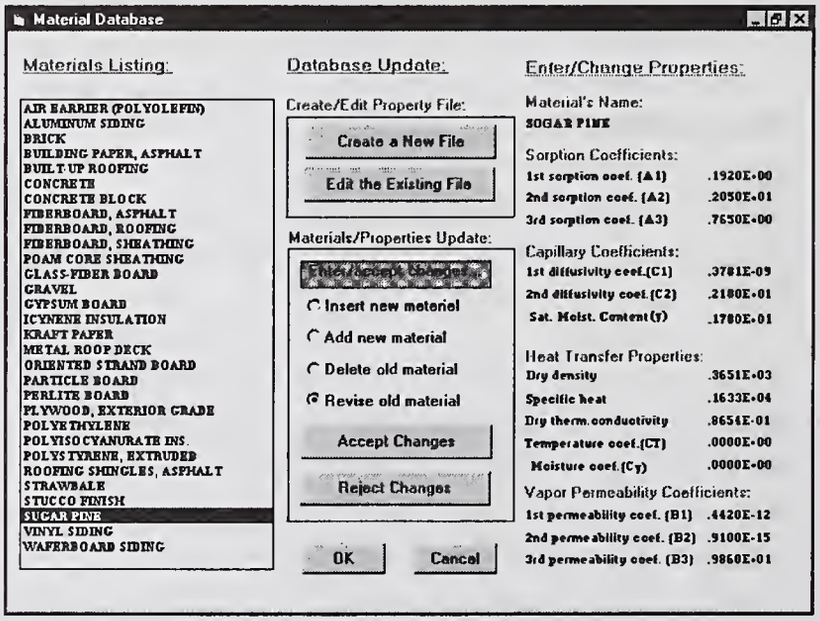

Figure 10. Material Database Dialog Box.

From this dialog box, you may create a new material database or update an existing material database. To update an existing material property database, click on **Edit the Existing File** command button. You may now perform one of the following options:

Inserting a new material above a selected material. Double-click on **Insert a new material**. Then double-click on the material above which the new material is to be inserted. You may now enter the new material name and its properties.

Add a new material below a selected material. Double-click on **Add a new material**. Then double-click on the material below which the new material is to be added. You may now enter the new material name and its properties.

Delete an existing material. Double-click on **Delete an old material**. Then double-click the material you want to delete.

Warning: Inserting, adding, and deleting a material changes the order of the materials in the material database. When these operations are performed in the middle of a MOIST session, the names of the materials given in the Construction Data Entry Box may be altered. Therefore, it is recommended that you perform these operations at the beginning of a MOIST session.

Revise an existing material. Double-click on **Revise properties**. Then double-click the material you want to revise. You may now revise the name of the material and its properties.

After you have completed updating the material property database, click on **Accept Changes**, if you want to incorporate the changes into the database. On the other hand, if you want to reject the changes, click on **Reject Changes**. Click **OK** to return to the MOIST Main Dialog Box. The **Cancel** button also returns you to the MOIST Main Dialog Box, but the changes you made are canceled.

This dialog box also permits you to create an entirely new material property database by clicking **Create a New File**. After making this selection, enter the material name and the property data for the first material. Then click on **Accept Changes**. Now to add additional materials, proceed in the following manner. Double-click on **Add New Material**. Then double-click on the last material given in the **Material Listing**. You may now enter the material name and the property data for the second material. Then click on **Accept Changes**. Proceed in this fashion until all the materials have been added. When you are done, click on **OK** to return to the MOIST Main Dialog Box. *It is worth mentioning that you may restore the original material property database at any time by clicking **Reset** in the MOIST Main Dialog Box.*

The material property data are defined below. From the Material Data Dialog Box, you may view the equation for the property by clicking on the property name.

Sorption Coefficients. The first three parameters pertain to the storage of water vapor in the material. They are used to relate the moisture content (γ) to the ambient relative humidity (ϕ).

$$\gamma = \frac{A_1\phi}{(1+A_2\phi)(1-A_3\phi)} \quad (1)$$

In the above equation, both γ and ϕ are expressed as a fraction. This equation is called the sorption isotherm function. The three parameters (A_1, A_2, and A_3) are determined by a fit of measured data for γ and ϕ. Here the sorption isotherm is assumed to be independent of temperature.

Capillary Coefficients. The next three parameters pertain to capillary transfer in a material. The first two parameters (C_1 and C_2) are coefficients of the following empirical correlation that relates liquid diffusivity (D_γ) to moisture content (γ):

$$D_\gamma = C_1\exp(C_2\gamma) \quad (2)$$

The liquid diffusivity (D_γ) and parameter (C_1) are expressed in m^2/s (ft^2/h). The parameter (C_2) is dimensionless.

The third parameter is the capillary saturated moisture content of the material expressed as a fraction. It is the moisture content of a material after it is submersed in water and allowed to reach equilibrium.

Heat Transfer Properties. The next two parameters are the dry density of the material expressed in kg/m^3 (lb/ft^3) and the specific heat of the material expressed in J/kg·K (Btu/lb·°F). The next three parameters are coefficients in the following empirical equation for the thermal conductivity (k) of the material:

$$k = k_{dry} + C_T(T-T_{ref}) + C_\gamma\gamma \quad (3)$$

where

k_{dry} = dry thermal conductivity, W/m·K (Btu/h·ft·°F)
C_T = temperature coefficient, $W/m\cdot K^2$ ($Btu/h\cdot ft\cdot °F^2$)
T_{ref} = reference temperature [24°C (76°F)]
C_γ = moisture coefficient, W/m·K (Btu/h·ft·°F)
T = temperature, °C (°F)
γ = moisture content, kg/kg (lb/lb)

Vapor Permeability Coefficients. The last three parameters pertain to water-vapor diffusion in a material. They are the coefficients for the relation between water-vapor permeability (μ) and ambient relative humidity (ϕ), or:

$$\mu = B_1 + B_2\exp(B_3\phi) \quad (4)$$

In the above equation, μ, B_1, and B_2 are expressed in kg/s·m·Pa (perm·inch) and ϕ is expressed as

a fraction. This equation is called the water-vapor permeability function. The three parameters (B_1, B_2, and B_3) are determined by a fit of measured data for μ and ϕ.

Moisture property data for building materials are published in the IEA Annex 24 - Material Properties Report (1996), Burch, et al. (1992), Richards, et al. (1992), Burch, et al. (1995), Tveit (1966), and Hansen (1986).

CHAPTER 5. RUNNING A MOIST ANALYSIS

From the MOIST Main Dialog Box (see Figure 4), click on the **Reset** command. This will reset the input data to their original state (as initially installed). Click the **Run** command to start the MOIST analysis sequence. The Run I.D. Dialog Box shown in Figure 11 will appear on your computer screen. You will need to enter a run ID number, filename, project title, analyzed by, and date. The completed Run I.D. Dialog Box is shown in Figure 11.

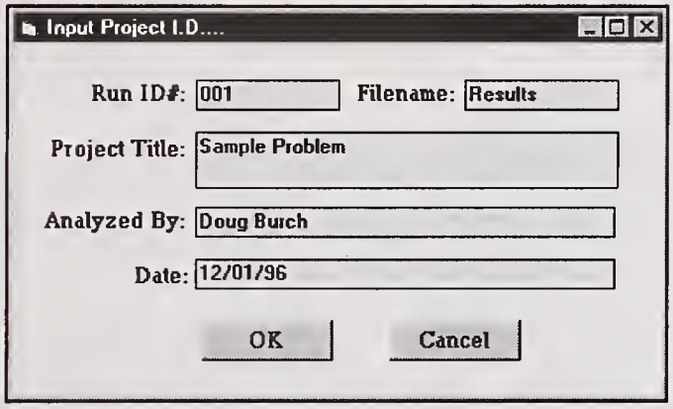

Figure 11. Run I.D. Dialog Box.

After you have completed the entries for this dialog box, click the **OK** button to proceed with the run. Alternatively, you may click the **Cancel** button to cancel the MOIST analysis and return to the MOIST Main Dialog Box. The Analysis Application Dialog Box shown in Figure 12 will appear on your computer screen. Click the **OK** button to proceed with the MOIST analysis.

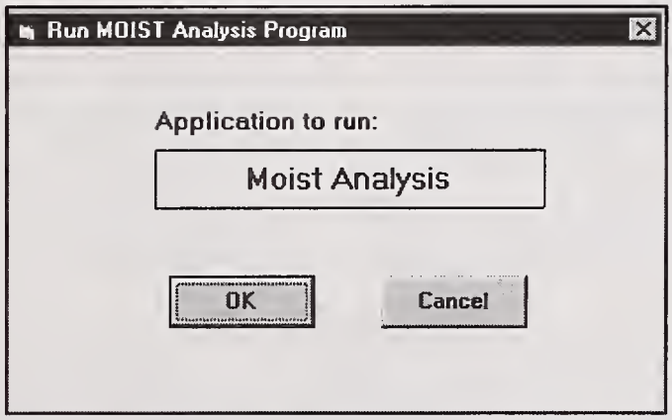

Figure 12. Analysis Application Dialog Box.

After clicking the **OK** button on the Run MOIST Analysis Program Dialog Box, the MOIST program reads in hourly WYEC weather data file for the analysis. The following message is displayed: "Please wait...reading in weather data." In the analysis intervals, if you specified a pre-conditioning period, then the following message will subsequently be displayed during the pre-conditioning calculation: "Please wait...pre-conditioning calculation in progress."

Note: If you specified the indoor climate model (see Figure 9), the MOIST program requires more time to process the weather data and prepare the indoor temperature and relative humidity conditions needed for the analysis.

During the analysis, the MOIST program displays a plot of the moisture content of the construction layers versus time of year on your computer screen (see Figure 13).

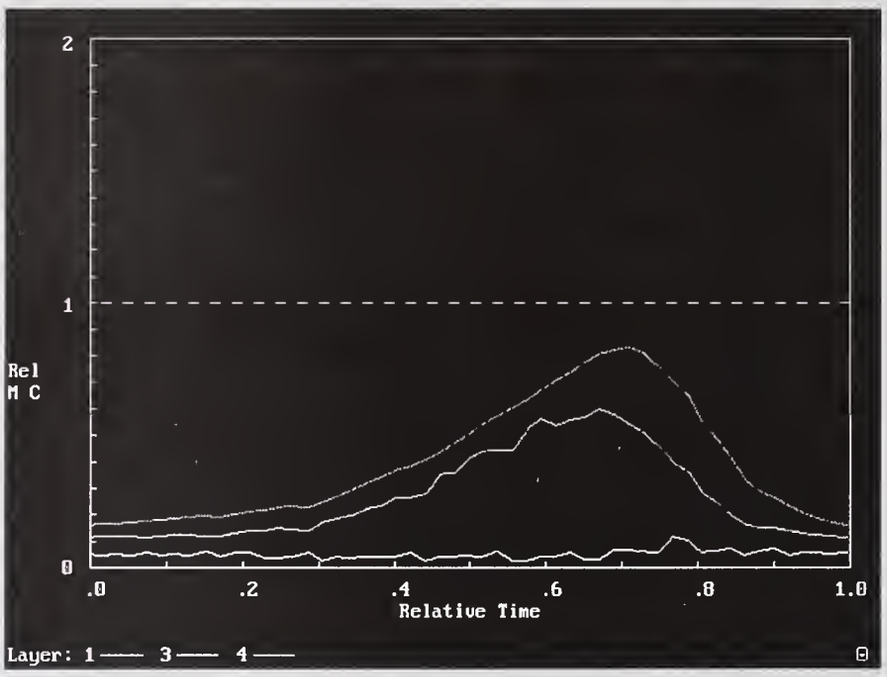

Figure 13. Screen Plot Displayed during Execution.

On a Pentium 166 MHZ computer, the MOIST program takes 50 seconds to run this sample problem. In the graph on the computer screen, the vertical axis displays the relative moisture content of the storage layers of the construction. The term "relative moisture content" is defined as the moisture content of the material layer divided by the moisture content of the material at maximum sorption. Maximum sorption is the moisture content of the material in equilibrium with saturated air at 97% RH. The dashed horizontal line in the center of the graph depicts a relative moisture content of 1. This is the critical moisture content above which liquid water appears in the large pore spaces of the material. Relative time is displayed on the horizontal axis. A relative time of 0 corresponds to the start of a simulation, and a value of 1 corresponds to the end of the simulation.

In the above plot, three curves for the sample problem (see Figure 5) are displayed. Layer 1 (lower curve) is the moisture content of the gypsum board, layer 3 (middle curve) is the asphalt fiberboard, and layer 4 (upper curve) is the sugar pine. Since the insulation is treated as a non-storage layer (layer 2), it is not shown in the plot.

Neat Feature: If you would like a hard copy of this computer screen plot, press the ***Print Screen*** *key*

after the plot is completed. This copies the screen plot onto the clipboard. After exiting the MOIST program, you may invoke the Windows Paint Program, and copy this screen plot into the Paint Program using the ***Paste*** *Command. This screen plot may subsequently be printed by selecting* ***Print*** *from the* ***File Menu.***

After the screen plot is completed, press the **Enter** key to continue. The program now will display a Finish-Analyze Box, if you are using a Microsoft Windows 95 operating system. A finish-Analyze Box is not displayed if you are using either a Microsoft Windows 3.1 or a Microsoft Windows NT operating system. If the MOIST program fails to complete the simulation, an error message will be displayed in this box. Press the **x** button in the upper right corner of the window to continue. The program returns to the MOIST Main Dialog Box (see Figure 4).

CHAPTER 6. PLOTTING RESULT GRAPHS

After you complete a MOIST simulation, you may view and plot result graphs from within the program. From **Plot graphs** of the MOIST Main Dialog Box (see Figure 4), double-click the output result that you want plotted.

The program now displays the Graphics Editing Dialog Box shown in Figure 14. From this dialog box, you can click the appropriate check boxes to select the variables you want plotted. In addition, you may accept or revise the x-axis and y-axis labels. When finished, you may click on the **Plot** command to view the plot or click on the **Cancel** command to return to the MOIST Main Dialog Box.

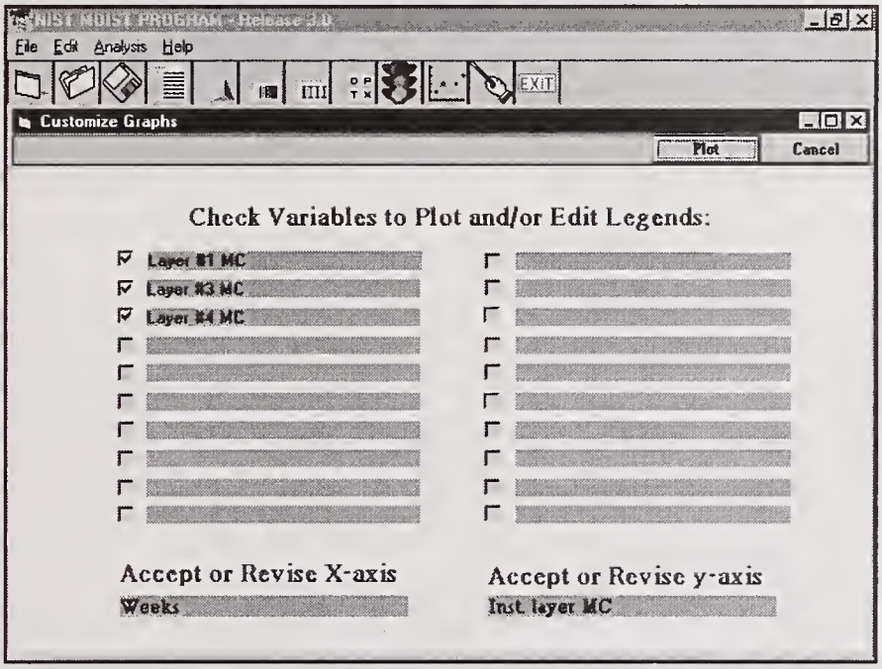

Figure 14. Graphics Editing Dialog Box.

After clicking the **Plot** command, the Graphing Dialog Box shown in Figure 15 is displayed. From this dialog box, you may click **Print** to send a copy of the plot to your printer. If you want to revise the variables plotted or revise the x-axis or y-axis label, click on **Revise**. You may also add a title to your plot by clicking **Title** and entering a title when prompted. You must click on **Revise** to

incorporate the title into the plot. When you are finished with this dialog box, click **OK** to return to the MOIST Main Dialog Box.

Note: When you plot the boundary conditions, two of the parameters are substantially smaller than the other parameters. Therefore, they are displayed as nearly zero values. If you would like to see a plot of these two parameters, then select only these variables on the Graphics Editing Dialog Box. This will produce a plot of these two parameters.

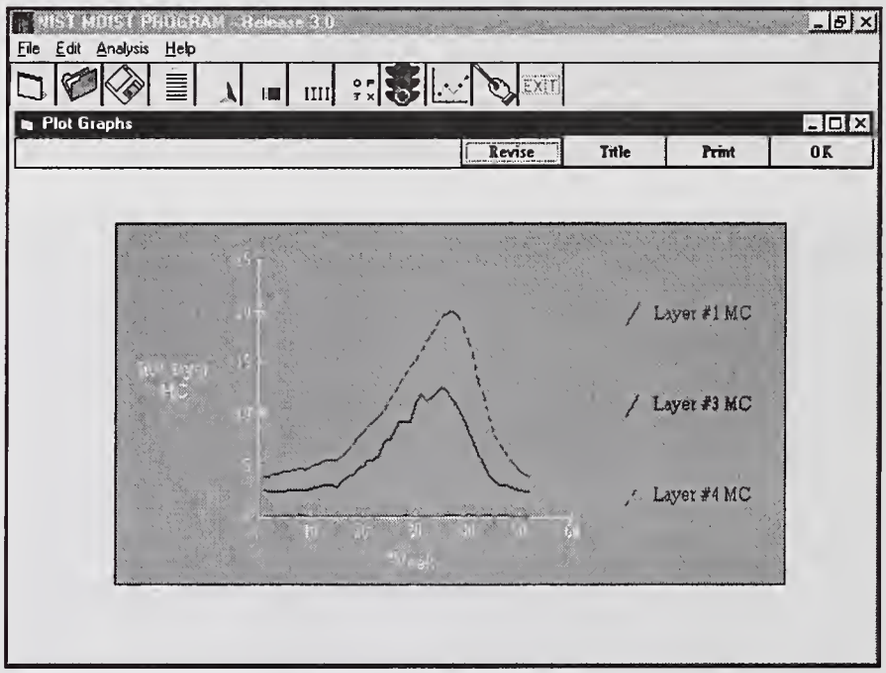

Figure 15. Graphing Dialog Box.

CHAPTER 7. GETTING A HARD COPY OF THE INPUT DATA

After you have plotted the results, you may want to get a hard copy of all the input data parameters. If you selected a full hard copy documentation, the output potentials (i.e., temperature, moisture content, water-vapor pressure, and logarithm of capillary pressure) will also be displayed after the input data parameters. From the MOIST Main Dialog Box (see Figure 4), click on **Present Results** and a report of the MOIST simulation will be displayed on your computer screen as shown in Figure 16. You can use the vertical scroll bar to move you through the complete set of input data. If you would like a hard copy of these results, then click **Print** and this report will be sent to your printer. Click **OK** to return to the MOIST Main Dialog Box.

CHAPTER 8. MANAGING FILES

After you run and analyze a project, you may save the project to a file. In this way, you will be able to open this project at a later time either to re-run it with revisions or to re-examine the results. When you save a project, all the input data parameters given in the dialog boxes, including the property data catalog of the materials, is saved to files (see Appendix B for a complete description of the files). The procedures for opening and saving project files are described below.

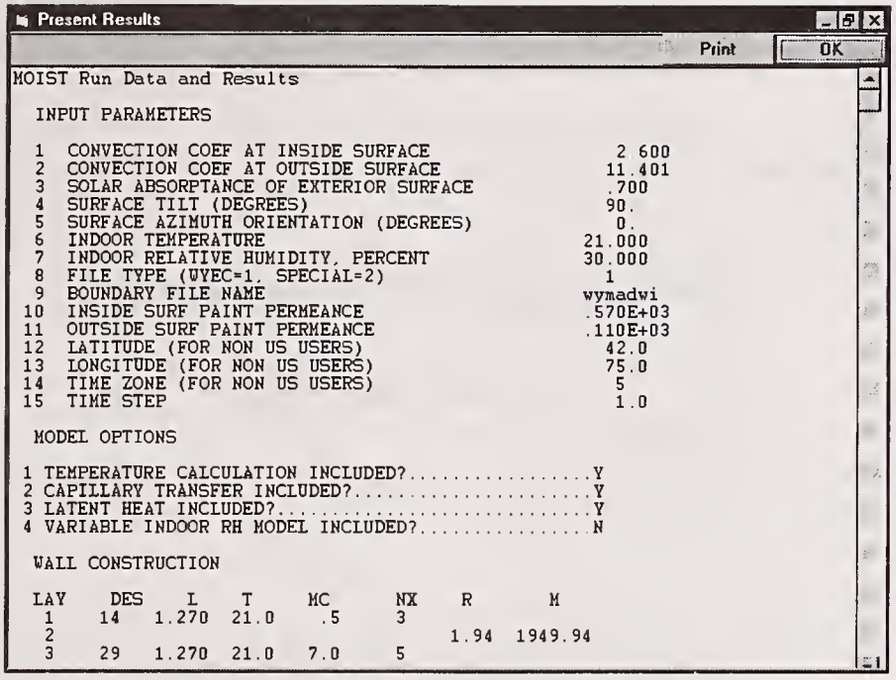
Present Results
Print
OK
MOIST Run Data and Results
INPUT PARAMETERS
1 CONVECTION COEF AT INSIDE SURFACE 2.600
2 CONVECTION COEF AT OUTSIDE SURFACE 11.401
3 SOLAR ABSORPTANCE OF EXTERIOR SURFACE .700
4 SURFACE TILT (DEGREES) 90.
5 SURFACE AZIMUTH ORIENTATION (DEGREES) 0.
6 INDOOR TEMPERATURE 21.000
7 INDOOR RELATIVE HUMIDITY, PERCENT 30.000
8 FILE TYPE (WYEC=1, SPECIAL=2) 1
9 BOUNDARY FILE NAME wymadwi
10 INSIDE SURF PAINT PERMEANCE .570E+03
11 OUTSIDE SURF PAINT PERMEANCE .110E+03
12 LATITUDE (FOR NON US USERS) 42.0
13 LONGITUDE (FOR NON US USERS) 75.0
14 TIME ZONE (FOR NON US USERS) 5
15 TIME STEP 1.0
MODEL OPTIONS
1 TEMPERATURE CALCULATION INCLUDED?.....Y
2 CAPILLARY TRANSFER INCLUDED?.....Y
3 LATENT HEAT INCLUDED?.....Y
4 VARIABLE INDOOR RH MODEL INCLUDED?.....N
WALL CONSTRUCTION
LAY DES L T MC NX R M
1 14 1.270 21.0 .5 3
2 1.94 1949.94
3 29 1.270 21.0 7.0 5

Figure 16. A Report of the MOIST Simulation.

Saving a Project to File

From **Manage projects** of the MOIST Main Dialog Box (see Figure 4), click on **Save Project**, and the Dialog Box for Saving Current Project shown in Figure 17 is displayed on your computer screen.

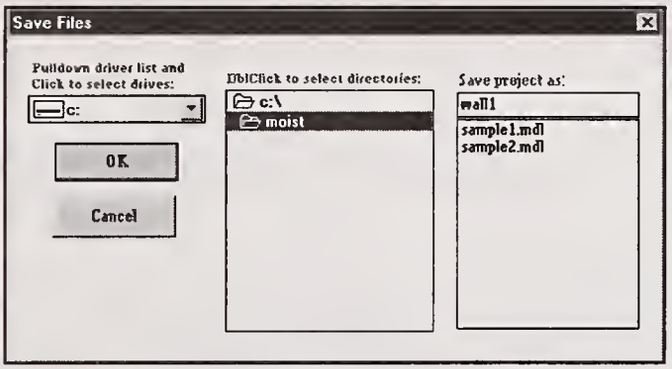

Figure 17. Dialog Box for Saving Current Project.

Under the **Pull down driver list**, click and select the drive onto which you wish to save the project. Then double-click on the directory into which you wish to save the project. To see a list of all the directories available, double-click on the root directory (i.e., c:\ in this example). You may either type in a new file name in the **Save project as** data box or select an existing project name by clicking and selecting one of the existing project files. Files names must be seven characters or less. *Do not enter a file extension because the MOIST program does that automatically.* If you select an existing file, then the new project will be copied over the existing project. The old data will be lost. Click **OK** to save the current project as named and to return to the MOIST Main Dialog Box. Clicking **Cancel** returns to the MOIST Main Dialog Box without saving the current project file.

Note: You can <u>not</u> save a MOIST project to file until after the MOIST run is completed. This is because the output results are saved along with a complete set of input data.

Opening an Existing Project File

From **Manage projects** of the MOIST Main Dialog Box (see Figure 4), click on **Open Project**, and the Dialog Box for Opening an Existing Project shown in Figure 18 will be displayed on your computer screen.

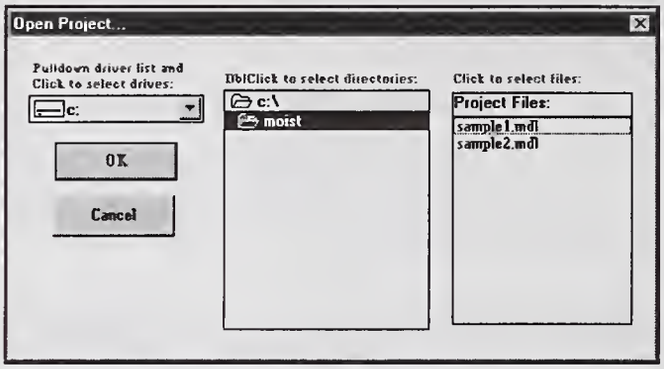

Figure 18. Dialog Box for Opening an Existing Project.

Under the **Pull down driver list**, click and select the drive from which you wish to retrieve the project. Then double-click on the directory from which you wish to retrieve the project. To see a list of all the directories available, double-click on the root directory (i.e., c:\ in this example). Click on the file name (which you wish to retrieve) in the **Project Files** data box. Click on **OK** to open the specified project file and to return to the MOIST Main Dialog Box. Click **Cancel** to return to the MOIST Main Dialog Box without opening the specified project file.

CHAPTER 9. ACHIEVING CONVERGENCE OF THE MATHEMATICAL SOLUTION

MOIST predicts the temperature and moisture content of the construction layers as a function of time of year using the finite-difference model described in Appendix A. In the model, each layer of the construction is subdivided into equal-size subvolumes. A heat and moisture balance is performed on the nodes at the center of these subvolumes. The number of nodes for each layer are specified in the Construction Data Entry Box (see Figure 5). The heat and moisture fluxes between nodes are predicted by linear approximation. As the number of nodes is increased, the approximate solution approaches the "exact" solution. However, the computer time also increases as the number of nodes is increased. Therefore, it is desirable to find the fewest number of nodes in each layer that achieves convergence of the mathematical solution.

An optimum number of nodes in a layer is determined by carrying out a series of simulations with an increasing number of nodes in the layer. The moisture content of the layer is plotted versus time of year for each of the simulations. An adequate number of nodes is deemed to exist when the predicted moisture content of the layer is nearly the same as a simulation with twice as many nodes. This process should be carried out for each of the layers. Some general guidelines on choosing an appropriate number of nodes is given below. These general guidelines should only be used as a starting point. *It is imperative that the above procedure be applied to make certain that the number of nodes for each layer is sufficient to achieve convergence of the mathematical solution.*

Each layer must have a minimum of two nodes. The total number of nodes in a construction (including all the layers) must not exceed 500.

When the construction layers operate in the hygroscopic regime (i.e., liquid water does not coalesce in the large pore spaces), the number of nodes needed in very permeable materials (e.g., gypsum board, fiberboard sheathing, etc.) is 2 per cm (5 per inch). In relatively impermeable materials (e.g., sugar pine and plywood), 8 nodes per cm (20 nodes per inch) are needed. In very thin layers (i.e., vapor retarders), two nodes are sufficient.

When the construction layers operate in the capillary regime (i.e., the surface rh of a material rises above 97% and its moisture content rises above maximum sorption), then at least ten times as many nodes are needed to accommodate the very large variations in moisture properties that occur in the wet-dry transition. When a layer gets wet only at one of its surfaces, the layer may be subdivided into two separate layers: a thin surface layer and a remainder layer. Considerably fewer nodes are needed to achieve convergence in the two separate layers compared with a single whole layer.

CHAPTER 10. MODELING LOW DENSITY INSULATIONS AND AIR SPACES

When modeling low density insulation (e.g., glass fiber blanket insulation and cellulose insulation), it is recommended that you treat the material as a non-storage layer. That is, it is recommended that you neglect the storage of heat and moisture in the layer. This will provide the MOIST model with the maximum amount of numerical stability. As a non-storage layer, you will specify the thermal resistance of the insulation expressed in $m^2 \cdot °C/W$ ($ft^2 \cdot h \cdot °F/Btu$) and water-vapor permeance expressed in $kg/m^2 \cdot s \cdot Pa$ (perm). The permeance for glass fiber insulation is equal to 1.69×10^{-10} $kg/Pa \cdot s \cdot m$ (116 perm·inch) divided by the thickness in meters (inches), and the permeance for cellulose insulation is equal to 1.37×10^{-10} $kg/Pa \cdot s \cdot m$ (94 perm·inch) divided by the thickness in meters (inches).

MOIST also has the capability of modeling low density insulation as a storage layer. However, when low density insulation is modeled in this fashion, the MOIST model may become unstable. In this situation, the moisture content in the insulation may experience unreasonable fluctuations or the become negative. This problem is caused by very large moisture transfer rates occurring in the insulation due to its very high permeability. Often a stable solution can be obtained by choosing a large number of finite-difference nodes in the insulation layer (e.g., > 30 nodes) and using a small time step (e.g., < 0.1 hour). It usually requires some trial-and-error choices for these two parameters to achieve a stable solution. Material properties for glass fiber insulation and cellulose insulation are given in the table below.

Low Density Insulation Properties		
Property	**Fiber Glass Insulation**	**Cellulose Insulation**
Sorption Coefficients:		
1st Sorption Coefficient (A1)	**0.001703**	**0.2737**
2nd Sorption Coefficient (A2)	**0.1E-07**	**5.953**
3rd Sorption Coefficient (A3)	**0.963**	**0.9995**
Capillary Coefficients:		
1st Diffusivity Coef. (C1)	**0.0**	**1.0E-8 (3.9E-4)**
2nd Diffusivity Coef. (C2)	**0.0**	**0.0**
Sat. Moisture Content (γ)	**0.0**	**4.6**
Heat Transfer Properties:		
Dry Density	**9.611(0.6)**	**44.05 (2.75)**
Specific Heat	**711.8 (0.17)**	**1382 (0.33)**
Dry Therm. Conductivity	**0.04327 (0.025)**	**0.04258 (0.0246)**
Temperature Coef. (C_T)	**0.0**	**0.0**
Moisture Coef. (C_γ)	**0.0**	**0.0**
Vapor Permeability Coef's:		
1st Permeability Coef. (B1)	**0.1824E-09 (125)**	**0.1372E-09 (94)**
2nd Permeability Coef. (B2)	**0.0**	**0.0**
3rd Permeability Coef. (B3)	**0.0**	**0.0**

Values in parenthesis are English unit values.

An air space is modeled as a non-storage layer. When the width of an air space is small (e.g., < 0.64 cm (0.25 in), it may be treated as a stagnant air layer having a permeability equal to 1.75×10^{-10} kg/Pa·s·m (120 perm·inch). The permeance is found by dividing the permeability by the air space thickness expressed in meters (inches). When the width of an air space is 1.3 cm (0.5 in) or larger, the air space becomes a convective air space. The exact value of the permeance of a convective air space may be calculated using the Lewis relationship. However, most moisture analyzes are not very dependent on the particular value used, providing that the value is reasonable. The authors recommend using a value 1.3×10^{-8} (230 perm) for all convective air space widths.

CHAPTER 11. FEEDBACK AND COMMENTS

The authors would greatly appreciate any comments that you have concerning MOIST. This feedback will us help develop improved releases in the future. Please send any comment(s) to:

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NOMENCLATURE

Symbol	SI Units	English Units	Definition
A_f	m^2	ft^2	House floor area
c_d	J/kg·°C	Btu/lb·°R	Dry specific heat
c_w	J/kg·°C	Btu/lb·°R	Specific heat of water
C_T	$W/m^2·°C^2$	$Btu/h·ft^2·°F^2$	Temperature coefficient for thermal conductivity
C_γ	W/m·°C	Btu/h·ft·°F	Moisture coefficient for thermal conductivity
C_v	$(L/s)^2·cm^{-4}·(m/s)^{-2}$	$cfm^2·in^{-4}·mph^{-2}$	Wind coefficient for whole house
$C_{\Delta T}$	$(L/s)^2·cm^{-4}·°C^{-1}$	$cfm^2·in^{-4}·°F^{-1}$	Stack coefficient for whole house
D_γ	m^2/s	ft^2/h	Liquid diffusivity
E	-	-	Emittance factor
h_{lv}	J/kg	Btu/lb	Latent Heat of Vaporization
$h_{c,i}$	$W/m^2·°C$	$Btu/h·ft^2·°R$	Convective heat transfer coef. at inside surf.
$h_{c,o}$	$W/m^2·°C$	$Btu/h·ft^2·°R$	Convective heat transfer coef. at outside surf.
$h_{r,i}$	$W/m^2·°C$	$Btu/h·ft^2·°R$	Radiative heat transfer coef. at inside boundary
$h_{r,o}$	$W/m^2·°C$	$Btu/h·ft^2·°R$	Radiative heat transfer coef. at outside boundary
H_{sol}	W/m^2	$Btu/h·ft^2$	Incident solar radiation onto a surface
k	W/m·°C	Btu/h·ft·°R	Moist thermal conductivity
k_{dry}	W/m·°C	Btu/h·ft·°R	Dry thermal conductivity
K	kg/m·s·Pa	lb/ft·h·inHg	Hydraulic conductivity
L_h	m^2	ft^2	Effective leakage area for whole house
$M_{e,i}$	$kg/m^2·s·Pa$	perm	Effective inside surface permeance
$M_{f,i}$	$kg/m^2·s·Pa$	perm	Air film permeance at inside surface
$M_{p,i}$	$kg/m^2·s·Pa$	perm	Paint permeance at inside surface
n	-	-	Hourly summation index
N	-	-	Current hour
p_l	Pa	inHg	Capillary pressure
p_v	Pa	inHg	Water vapor pressure
$p_{v,i}$	Pa	inHg	Water vapor pressure of indoor air
t	s	h	Time
T	°C	°R	Temperature
T_i	°C	°R	Indoor temperature
T_{ref}	°C	°R	Reference temperature [24°C(24°F)]
T_m	°C	°R	Mean temperature
T_{sky}	°C	°R	Sky temperature
T_o	°C	°R	Outdoor air temperature
v	m/s	mph	Average wind speed
$\dot{V}_{h,m}$	m^3/s	cfm	House mechanical ventilation rate
$\dot{V}_{h,n}$	m^3/s	cfm	House natural ventilation rate
$\dot{V}_{h,t}$	m^3/s	cfm	Total house ventilation rate
y	m	ft	Distance
$\dot{W}$	kg/s	lb/h	Moisture generation rate
Z(n)	-	-	Exponential weighting factors
γ	kg/kg	lb/lb	Moisture content on dry mass basis
κ	$kg/s·m^2$	$lb/h·ft^2$	Sorption constant per unit floor area
ρ_a	kg/m^3	lb/ft^3	Air density
ρ_d	kg/m^3	lb/ft^3	Dry material density
σ	$W/m^2·°C^4$	$Btu/h·ft^2·R^4$	Stefan-Boltzmann constant
μ	kg/m·s·Pa	perm	Water-vapor permeability
τ	s	h	Moisture storage time constant
ϕ	-	-	Relative humidity
ϕ_i	-	-	Indoor relative humidity
$\phi_{i,\tau}$	-	-	Hygroscopic memory
ω_i	kg/kg	lb/lb	Indoor air humidity ratio
ω_o	kg/kg	lb/lb	Outdoor air humidity ratio

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APPENDIX A. THEORY OF MOIST (RELEASE 3.0)

This section describes the theory for MOIST (Release 3.0). In the previous version of the MOIST model (Release 2.1), temperature was used as the potential for heat flow, and moisture content was used as the potential for moisture flow. In the new model, temperature is used as the potential for heat flow, water-vapor pressure is used as the potential for vapor transfer, and capillary pressure is used as the potential for liquid flow.

Assumptions

Some of more important assumptions of the analysis are:

- heat and moisture transfer are one dimensional;
- the construction is airtight, and the transport of moisture by air movement is neglected;
- the wetting of exterior surfaces by rain is neglected;
- snow accumulation on horizontal surfaces, and its effect on the solar absorptance and thermal resistance is neglected; and
- the transport heat by liquid movement is neglected.

Other assumption are discussed below.

Basic Transport Equations

The basic transport equations are taken from Pedersen[1] (1990) and are briefly presented below.

Within each material layer of the construction, the moisture distribution is governed by the following conservation of mass equation:

$$\frac{\partial}{\partial y}\left(\mu \frac{\partial p_v}{\partial y}\right) - \frac{\partial}{\partial y}\left(K \frac{\partial p_l}{\partial y}\right) = \rho_d \frac{\partial \gamma}{\partial t} \qquad \text{(A-1)}$$

The first term on the left side of eq (A-1) represents water-vapor diffusion, whereas the second term represents capillary transfer. The right side of eq (1) represents moisture storage within the material. The potential for transferring water vapor is the vapor pressure (p_v) with the permeability (μ) serving as a transport coefficient. The potential for transferring liquid water is the capillary pressure (p_l) with the hydraulic conductivity (K) serving as the transport coefficient. The signs on the first two terms are different because water vapor flows in the opposite direction of the gradient in water vapor

[1] Carsten Pedersen has changed his name to Carsten Rode.

pressure, and capillary water flows in the same direction of the gradient in capillary pressure. Other symbols contained in the above equation include the dry density of the material (ρ_d), moisture content (γ), distance (y), and time (t). The sorption isotherm (i.e., the relationship between equilibrium moisture content and moisture content) and the capillary pressure curve (i.e., the relationship between capillary pressure and moisture content) were used as constitutive relations in solving eq (1).

The hydraulic conductivity (K) in eq (A-1) is related to the liquid diffusivity (D_γ) by the relation:

$$K = -\frac{\rho_d D_\gamma}{\frac{\partial p_l}{\partial \gamma}} \qquad \textbf{(A-2)}$$

where the term in the denominator of the right side of the equation is the derivative of the capillary pressure with respect to moisture content. When the temperature is above freezing, the liquid diffusivity is calculated using eq (2) given in the main body. When the temperature is below freezing, the liquid diffusivity is taken to be zero.

The temperature distribution is calculated from the following conservation of energy equation:

$$\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right) + h_{lv}\frac{\partial}{\partial y}\left(\mu\frac{\partial p_v}{\partial y}\right) = \rho_d(c_d+\gamma c_w)\frac{\partial T}{\partial t} \qquad \textbf{(A-3)}$$

The first term on the left side of eq (3) represents conduction, whereas the second term is the latent heat transfer derived from any phase change associated with the movement of moisture. The right side of eq (2) represents the storage of heat within the material and accumulated moisture. Symbols in the above equation include temperature (T), the dry specific heat of the material (c_d), the specific heat of water (c_w), and latent heat of vaporization (h_{lv}).

In eq (A-1), the water vapor permeability (μ) and the hydraulic conductivity (K) are strong functions of moisture content. In eq (A-3), the thermal conductivity (k) is also a function of temperature and moisture content (see eq (3) in the main body).

Adjacent Layer Boundary Conditions

The temperature, water-vapor pressure, and capillary pressure are continuous at adjacent material layers.

Indoor Boundary Conditions

At the indoor boundary of the construction, the moisture transfer through an air film and paint layer (or wallpaper) at the indoor surface is equated to the diffusion transfer into the solid material surface, or:

$$M_{e,i}(p_{v,i} - p_v) = -\mu\frac{\partial p_v}{\partial y} \qquad \textbf{(A-4)}$$

where the quantities are evaluated at the indoor boundary. Here, an effective conductance ($M_{e,i}$), defined by:

$$M_{e,i} = \frac{1}{\frac{1}{M_{f,i}} + \frac{1}{M_{p,i}}} \qquad \textbf{(A-5)}$$

has been introduced. The effect of a thin paint layer is taken into account as a surface conductance ($M_{p,i}$) in series with the convective mass transfer coefficient ($M_{f,i}$) associated with the air film.

At the same boundary, the heat transferred through the air film, ignoring the thermal resistance of the paint layer, is equated to the heat conducted into the indoor boundary, giving:

$$(h_{r,i} + h_{c,i})(T_i - T) = -k\frac{\partial T}{\partial y} \qquad \textbf{(A-6)}$$

where all quantities are evaluated at the indoor surface.

Outdoor Boundary Conditions

At the outdoor boundary of the construction, a similar set of equations are applied to compute the moisture transfer. The heat conducted into the outdoor boundary and the absorbed solar radiation is set equal to the heat loss to the outdoor air by convection and radiation, or:

$$-k\frac{\partial T}{\partial y} + \alpha H_{sol} = h_{c,o}(T - T_o) + h_{r,o}(T - T_{sky}) \qquad \textbf{(A-7)}$$

where all quantities are evaluated at the outdoor surface. Here $h_{r,o}$ is the radiative heat transfer coefficient defined by the relation:

$$h_{r,o} = E\sigma(T_s + T_{sky})(T_s^2 + T_{sky}^2) \qquad \textbf{(A-8)}$$

where E is the emittance factor which includes the surface emissivity and the view factor from the outdoor surface to the sky, T_s is the surface temperature, and T_{sky} is the sky temperature. The solar radiation (H_{sol}) incident onto exterior surfaces having arbitrary tilt and orientation was predicted using algorithms given in Duffie and Beckman (1991). The sky temperature was calculated using an equation developed by Bliss (1961).

Variable Indoor Humidity Model

When the interior of a residential building can be modeled as single zone with a uniform temperature and relative humidity, the MOIST program has an option to permit the indoor relative humidity to vary during the winter. *The variable indoor relative humidity feature is only applicable to residential buildings and should not be applied to non-residential applications.* When this option is selected, the indoor conditions are determined in the following fashion.

Space Heating Operation. When the daily average outdoor temperature is less than or equal to the balance point temperature for space heating, the house operates in a space heating mode. The indoor temperature is taken to be equal to the heating set point temperature. The indoor relative humidity is permitted to vary and is calculated from an indoor humidity model by TenWolde (1994).

The rate of moisture production by the occupants is equal to the rate of moisture removed by natural and/or forced ventilation plus the rate of moisture storage at interior surfaces and furnishings, or:

$$\dot{W} = \rho_a \dot{V}_{h,t}(\omega_i - \omega_o) + \kappa A_f(\phi_i - \phi_{i,\tau}) \qquad \textbf{(A-9)}$$

Using the psychometric relationship between humidity ratio (ω) and relative humidity (ϕ) as a constitutive relation, the above equation may be solved for the indoor relative humidity.

The hygroscopic memory ($\phi_{i,\tau}$) is computed from the scanning function:

$$\phi_{i,\tau} = \frac{\sum_{n=N-4\tau}^{N-1} Z(n)\phi_i(n)}{\sum_{n=N-4\tau}^{N-1} Z(n)} \qquad \textbf{(A-10)}$$

In the above equation, the hygroscopic memory at the current time step N is found from a past-history relative humidity time series. The time series is evaluated over four time constants (τ). The exponential weighting factors Z(n) are defined as:

$$Z(n) = e^{-(N-n)/\tau} \qquad \textbf{(A-11)}$$

TenWolde (1994) has conducted experiments and determined the sorption constant per unit floor area (κ) and the time constant (τ) for manufactured and site-built houses.

The natural ventilation rate for the house is predicted by the single-zone Lawrence Berkeley Laboratory (LBL) infiltration model developed by Sherman and Grimsrud (1980) and described by ASHRAE (1993) which is given by:

$$\dot{V}_{h,n} = L_h\left[C_{\Delta T}|T_i - T_o| + C_v v^2\right]^{0.5} \qquad \textbf{(A-12)}$$

When mechanical ventilation $V_{h,m}$ is present, the total ventilation rate $V_{h,t}$ in eq (A-9) is determined by the relation (Palmiter and Bond 1991):

$$\begin{aligned} &\text{If } \dot{V}_{h,m} < 2\dot{V}_{h,n}\,, \quad \dot{V}_{h,t} = \dot{V}_{h,n} + 0.5\,\dot{V}_{h,m} \\ &\text{If } \dot{V}_{h,m} \geq 2\dot{V}_{h,n}\,, \quad \dot{V}_{h,t} = \dot{V}_{h,m} \end{aligned} \qquad \textbf{(A-13)}$$

It should be noted that in eq (A-13), $V_{h,m}$ is the actual mechanical ventilation rate produced by the ventilation equipment installed in the house, as opposed to the rated value. The actual value is typically about half of the rated value (Tsongas 1990).

In the hourly calculations, the dew-point temperature of the indoor air is compared with the temperature of the inside glass surface to determine if window condensation occurs. When condensation occurs, the vapor pressure of the indoor air is taken to be equal to the saturation pressure at the inside glass surface. The indoor relative humidity is calculated from the indoor temperature and vapor pressure using psychometric relationships.

Space Cooling Operation. When the daily average outdoor temperature is greater than or equal to the balance point temperature for space cooling, the house operates in a space cooling mode. The indoor temperature and relative humidity are maintained at constant specified values.

Window Opened Operation. When the daily average outdoor temperature is greater than the balance point for space heating and less than the balance point for space cooling, then neither space heating nor space cooling are required. It is assumed that the windows are opened, and the indoor temperature and relative humidity are equal to the outdoor values. When the space cooling equipment is turned off, it was assumed that the occupant will open the windows, and the building again operates in a floating mode.

Solution Procedure

A FORTRAN 77 computer program, called the MOIST 3.0, was prepared to solve the above system of equations. Finite-difference equations were developed to represent the basic moisture and heat transport equations (eqs (A-1) and (A-3)).

APPENDIX B. DESCRIPTION OF FILES IN MOIST DIRECTORY

The following files should be in the MOIST directory after the program is installed.

MOIST.EXE: This is the Visual Basic program module that performs the Window environment input/output processing for the MOIST program.

ANALYZE.EXE: This is the FORTRAN program module that performs the heat and moisture transfer analysis.

MSTRST.EXE: This is the Visual Basic program module that resets the input data to the original state as installed.

Run-Time Data Files

The following files are input data files for the MOIST program:

File Name	File Description
PDATA.DAT	Property Data of the Materials
DEFSET.DAT	General Input Parameters
CONST.DAT	Building Construction Data
PEROD.DAT	Analysis Intervals
INDOOR.DAT	Indoor Parameters for Calculating Variable Indoor RH
OPTS.DAT	Analysis Options
UNITS.DAT	Selected System of Units
CHECK.DAT	Diagnostic Parameters

A corresponding set of eight files with a **BCK** extension are the original MOIST files which are used to reset the input data to the original state as installed.

ASHRAE WYEC Weather Files:

File Name	File Description
WYMADWI	Madison, WI weather data
WYBOSMA	Boston, MA weather data
WYATLGA	Atlanta, GA weather data
WYLKCLA	Lake Charles, LA weather data
WYPOROR	Portland, OR weather data
WYWASDC	Washington, DC weather data

RESULT FILES

The following files are output files generated by the MOIST program.

File Name	File Description
RESULTS.BND	boundary conditions for a simulation
RESULTS.MC	instantaneous layer moisture contents
RESULTS.SMC	instantaneous surface moisture contents of construction layers
RESULTS.SRH	instantaneous surface relative humidities of construction layers
RESULTS.ARH	weekly-average surface relative humidities of construction layers
RESULTS.OUT	summary of all input data for a MOIST project
RESULTS.AQ	boundary heat fluxes
RESULTS.MF	boundary moisture fluxes
RESULTS.AR	time-avg. thermal resistance of construction
RESULTS.AST	time-avg. surface temperatures of construction layers

A corresponding set of nine files with a file name **RESULT** with the above extensions are the original MOIST result files as installed.

FILE MANAGEMENT

These files contain information on saved MOIST projects. File *.ABT contains run identification information on saved models, File *.MDL contains input data for saved models, and File *.RST contains analysis results for saved models. Here the "*" refers to the run name assigned by the user. These saved project files may be retrieved during a MOIST session using the **Open Project...** command button.

If you would like to archive saved files, then copy the above three files for save projects onto a floppy disk drive.

APPENDIX C. USING NON-WYEC WEATHER DATA

This appendix describes how to use the MOIST program with non-WYEC weather data.

First you will need to convert your weather data file into WYEC format. Here you will need to give your reformatted weather data file a unique seven-character file name that differs from the standard names given to WYEC files. The first two letters of the file name must be "WY." A WYEC weather data file contains 8760 hours (or 365 days) of hourly weather data. Each hour is represented by a row of ASCI data. Beginning with hour 0 of January 1, the hourly weather data must be placed in the following format:

Item	Field Position	Field Description
1	6-8	Dry Bulb Temperature, °F
2	9-11	Wet Bulb Temperature, °F
3	12-14	Dew Point Temperature, °F
4	15-17	Wind Direction
5	18-20	Wind Speed, knots
6	21-24	Station Pressure X 100, inHg
7	56-59	Solar Radiation X 10, Langleys
8	74-75	Month
9	76-77	Day
10	78-79	Hour (0 to 23)
11	80	Snow Indicator

In the above table, "field position" refers to the location of the data item in a horizontal field of data. Items 2, 4, 6, and 11 are not used by the MOIST program and values of zero should be used in the designated fields. Note that the station pressure is multiplied by 100. A station pressure of 29.92 inHg is entered as 2992. Similarly, the solar radiation is multiplied by 10, and a solar radiation of 10.1 Langleys is entered as 101.

Next, you will need to place this file in the MOIST directory. From the Input Parameters Dialog Box, you may now select this weather data file and enter the latitude, longitude, and time zone for the weather data location. When the program runs, it will used your new weather data file.

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